PERFORMANCE EVALUATION OF COORDINATED SIGNALIZED INTERSECTIONS WITH TRANSYT - 7F MODEL

by

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DEDICATED

TO

MY LOVING PARENTS

10/8/88

CERTIFICATE

This is to certify that the thesis entitled 'PERFORMANCE EVALUATION OF CO-ORDINATED SIGNALIZED INTERSECTIONS WITH TRANSYT-7F MODEL' submitted by K. Saravana Kumar in partial fulfilment of the requirements for the degree of Master of Technology of the Indian Institute of Technology, Kanpur, is a bonafide research work carried out by him under my supervision and guidance. The work embodied in this thesis has not been submitted else where for the award of a degree.

7 August, 1988

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ABSTRACT

Most of the Indian cities are growing at a faster rate there by increasing traffic on their roads. One of the problems facing the Indian cities is the eve rincreasing travel demand resulting in traffic congestion, large travel times, high travel costs, accidents, crowded public transport, environmental pollution and poor conditions for pedestrians. One of the reasons for this can be attributed to poorly designed and ineffective traffic control measures provided at the intersections. Currently available analytical methods and computer programs offer excellent capabilities in designing efficient signal timings plan and optimizing offsets for the coordination of a series of signalised intersections. The TRANSYT-7F Model is the most acclaimed and successful one, of such models currently used, and hence used for the present study.

The main aim of the present study is to evaluate the performance of the signalized intersections for various conditions of traffic flow as predicted by the model so that the information can be used to design the best signal settings at the intersections. In the first case study a three intersection urban corridor is considered and the impact of various flow parameters identified, such as flow level of traffic,approach speed. Intersection spacing, platoon dispersion factor (PDF) and signal timing parameter cycle length,on the measures of effectiveness (MOE) evaluated by

the model in determining the performance such as average delay, stops, fuel consumption, performance index (PI) and the average speeds of the vehicles in the network are studied by performing sensitivity analysis. Another case study of a higher magnitude problem, a six-intersection urban corridor is taken up and the analysis is carried out in the similar lines as the first case study. Graphs are drawn between the various MOE and the parameter under study and the results are discussed. Also to ease the tedious and error prone process of inputting a large input data required by the TRANSYT-7F a user friendly interactive input program is also developed. The results of the study are helpful in developing better signal timings plan, better signal inter connection and smooth traffic operations.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND:

Most of the cities in India are growing at a faster rate there by increasing the traffic on their roads. One of the problems facing the Indian cities is the ever increasing traffic demand resulting in traffic congestion,large travel times, high travel costs, parking difficulties, accidents, corwded public transports, environmental pollution and poor conditions for pedestrians.

One of the reasons for the above problems can be attributed to the heterogeneous mixture of traffic on urban roads, ranging from slow moving non-motorized vehicles to fast moving motor vehicles. The heterogeneous traffic which constitute cars, trucks, scooters, autos, public transport, buses, bullock carts, rickshaws and cycle represent considerable variations in their dimensions, speeds, acceleration and decelleration capabilities and other operating characteristics. These result in significant amount of vehicle interactions such as change in vehicle speeds, performing overtaking operations, stopping at intersections for want of green signal etc.

Apart from the mixed traffic problems there are other problems associated with the system such as effective traffic control measures at the intersections. The control measures

are mostly isolated fixed time signal control. The signal settings are not revised from time to time to cope up with the changes in traffic demand. Moreover there is no proper co-ordination of signals at successive intersections to provide for smooth flow of traffic without any stoppages as they pass through several intersections along a corridor etc.

1.2 STATEMENT OF THE PROBLEM:

The increase in levels of traffic congestion along major urban signalized arterials makes efficient traffic manageme and utilization of arterial facilities important considerations. Significant improvements in traffic flow and reductions in vehicular delay may be realized by adopting effective signal timing design methods and inter-connecting individual, isolated intersections into a co-ordinated signal system.

Current analytical methods and computer programs offer capabilities for designing efficient signal timing plans and also optimizing traffic signal co-ordination for a series of signalized intersection. Of all the computer package available TRANSYT-7F is considered the most popular and the successful one in achieving the above objectives. Since the latest version of the TRANSYT-7F package has been available with the Institute, in the present work an attempt is made to implement the package for developing signal timings plan for a busy urban corridor.

The evaluation of vehicle performance at the intersections, as predicted by the model, such as average delay, stopped delay, fuel consumption, performance index, average

delay, speed of the network etc. can be used to design best signal settings using the model. Since the model has not been tested earlier here, it is thought necessary to test the sensitivity of the model in predicting traffic performance at intersections for various flow characteristics such as flow level of traffic, speed of vehicles, spacing of intersections, and signal timing parameters such as cycle length etc. Since the model requires large input data and the coding of it is a tedious and error prone process, the development of a user friendly interactive computer program would help in solving the problem to a large extent.

1.3 SCOPE OF STUDY:

The main aim of the present study is to evaluate the performance of the signalized intersections considering various measures of effectiveness such as average delay, stopped-delay, performance index, fuel consumption, back up of queue etc. as predicted by the model TRANSYT-7F. Hence the details of the present study can be described as follows:

(i) The TRANSYT-7F (version 2.0, release 4,1984) program, originally written in Ansi Fortran-66 has been updated in its latest release with certain FORTRAN-77 features. Because of the non-availability of the above compiler with the DEC-1090 computer system used for the present work, some minor modifications had to be made to the program to make it compatible with DEC-1090 computer sys

(ii) TRANSYT-7F requires enormous amount of input data and coding the necessary input data is a tedious and error prone process. A self-explanatory user friendly interactive computer program is developed to solve the above problem to a large extent.

(iii) To study the performance measure values at intersections as predicted by TRANSYT-7F model, a case study of a three intersection-signalised urban corridor is chosen and measures of effectiveness analysed for varying flow characteristics such as flow level on links, speed of flow, intersection spacing, platoon dispersion factor and signal timing parameter such as cycle length etc.

(iv) To further study the impact of various flow characteristics, identified as predominant by the model, as in the previous case study, a higher magnitude problem, i.e. a six-intersection co-ordinated urban corridor is considered, and the sensitivity analysis performed, as in the previous case study. Finally the two case studies are compared and the results interpretted.

CHAPTER 2

TRAFFIC SIGNAL SYSTEMS DESIGN

2.1 INTRODUCTION:

Time sharing intersections give the right of way first to one set of movements and then to another depending on the physical lay out of the intersection, the type of control, and traffic demands. This form of control can be obtained either through automatic traffic signals or by police direction. In our present discussion most of the emphasis will be placed on traffic signals. Traffic signals are control devices which would alternatily direct the traffic to stop and proceed at intersections using red, yellow and green light signals automatically. The main requirements of the traffic signals are, to draw attention, provide meaning and time to respond and to have minimum waste of time.

The major emphasis in the criteria for signal control is the volume of traffic entering the intersection and its crossing and turning movements. The capacity of a signalised intersection depends on physical factors of the roads such as road way width, number of lanes, geometric design of intersection and also the green and red phases of the traffic signal. In addition, the capacity is affected by operational and control factors, such as number of turning movements, number and size of commercial vehicles, pedestrian traffic, peak hour demands, parking regulations, turn control, traffic signal characteristics and abutting land use.

2.2 APPROACHES FOR TRAFFIC SIGNAL DESIGN:

Most of the popular design methods of signal timings are macroscopic in nature. Some apply analytical equations and some use excellent operations research techniques to arrive at optimum signal timings plan. But the basic objectives of all of these, include most of the following considerations.

- Minimum delay
- Minimum queue length
- Minimum probability of cycle failure
- Minimum fuel consumption.

Webster (1958) , Webster and Wardrop (1962) and Webster and Cobbe (1966) made extensive analysis of traffic flow behaviour at intersections. They dealt with random nature of traffic flow. A set of formulae has been derived for calculations of average delay per vehicle, total intersection delay, aproximate cycle length based on minimum delay considerations, signal cycle splits, degree of saturation etc. The results were obtained from simulation study, continued with theoretical analysis and checked against field data. The delay formulae and its minimization are both approximate and the results apply only when there is no oversaturation. Bone and Martin and Harvey (1962-64), Miller (1963-1964) and many others have also derived formulae for calculating optimum signal timings for an isolated intersection based on the use of delay as a measure of intersection performance

Allsop (1972) developed a method of finding signal setting that minimize the estimated average delay per unit time to all

traffic passing through the intersection , subject to certain constraints with respect to green time, cycle length and approach capacity. An iterative procedure is followed to obtain delay minimising settings. This method is also however applicable, only when there is no over saturation. A model for an inter-section which is over saturated during rush period is developed by Mayne (1979). The model calculates optimum settings of signal timings, taking mean maximum queue size as one of the important constraints.

While designing signal systems for an urban traffic corridor or a road network the design of offsets between the signals are also important. Lot of research has also been done in this area for determining optimum offsets using various mathematical techniques. Hiller developed the continuation method, a procedure which calculates optimal offsets for series and parallel signalized networks using descrete-delay offsets function. Little (1960) used mixed mixed integer programming for computation of optimal offsets among the traffic signals of arterial systems, aiming at the maximization of band width for flow.

2.3 OPTIMIZATION:

Many computerised models have been developed which use various optimizing techniques for determining optimal cycle length phase length and optimal offsets. Models like SIGRID and SIGOP consider the flows on the links but do not compute global optimum. Here random research technique is used for optimization of offsets

Robertson (1967) developed an efficient computational programme based on combination method. Gastner (1972) used dynamic programming for formulating combination method. Gartner et al. (1975-76) made an attempt, to the problem of computation of optimal offsets and simultaneous optimization of all the control variables like offsets, Cycle time and green splits by using mixed integer programming technique, which aims at minimizing global delay on the network. This model is known as MITROP. Helmut (1975) developed a model for progressively timedssignal system. The model employs optimization technique as maximization of band width which is a function of cycle length and speed.

As discussed above there are many models developed for use in traffic signal designing. The most popular and successful model, TRANSYT-7F has been used in the present work. This model is based on the original model developed by Robertson (1967). It became popular and under-went a series of improvements. The TRANSYT-7F model determines optimum traffic signal settings for a fixed time control on a network.

TRANSYT-7F program has two main elements- (i) the simulation, which is used to calculate the performance index of the network for a given set of signal timings and (ii) optimization routine, for traffic signal timings.

The simulation model is macroscopic and calculates, for a given set of signal timings, on a link by link basis, the average expected behaviour of the vehicles, as they move through a network. It also takes into account the random behaviour of individual drivers, while computing average delay values. The

TRANSYT-model considers the arrival flow pattern at the down stream intersection, as a function of the upstream discharge pattern, displaced in time and speed. A platoon discharge algorithm, that simulates the normal dispersion of platoons as they travel down stream is used. The model simulates traffic flow in small time increments, so its representation of traffic is detailed than other macroscopic models, that assume uniform distribution with in the traffic platoon.

The optimization routine of the model, calculates an optimal set of offsets and the phase lengtn for a given cycle length, by minimizing an objective function known as the performance index (PI). PI is a linear combination of delay and stops. The model assumes that the vehicles that are delayed are also stopped. This assumption is made to properly model 'slow down' when the vehicles actually do not stop. The optimization method employed is the hill climbing technique which iterates over the network to attain optimum values of offsets and phase lengths.

Signal timings are usually developed with primary emphasis on minimizing delay, but fuel consumption is often included as one of the design criteria. The TRANSYT-7F also includes a model, which calculates the fuel consumption in a co-ordinated fixed time-signal controlled network.

CHAPTER 3

TRANSYT-7F MODEL

3.1 PROGRAM OVERVIEW:

The TRANSYT model was developed by Mr. Dennis I. Robertson of the U.K. in 1967. The first version was written in machine code and converted into FORTRAN and later the program has undergone several changes and improvements over the years. The present version of TRANSYT-7F is based on the version TRANSYT-7 (1978) developed by TRRL (Transport and Road Research Laboratory).

TRANSYT-7F is a macroscopic, deterministic simulation and optimization model. The program can be used for both analysi (simulation) and design (optimization) of alternative fixed-time signal control strategies. The program has modular construction, with each subprogram serving a specific function. There are a total of 54 such subprograms. Each subprogram can be categorized in one of the following major program functional areas.

- Preprocessor - input processing
- Model - simulation and optimization submodels
- Post processor - output processing.

Preprocessor: The primary function of the preprocessor is to read the input cards and process them. The second major function of the preprocessor is to generate a series of link

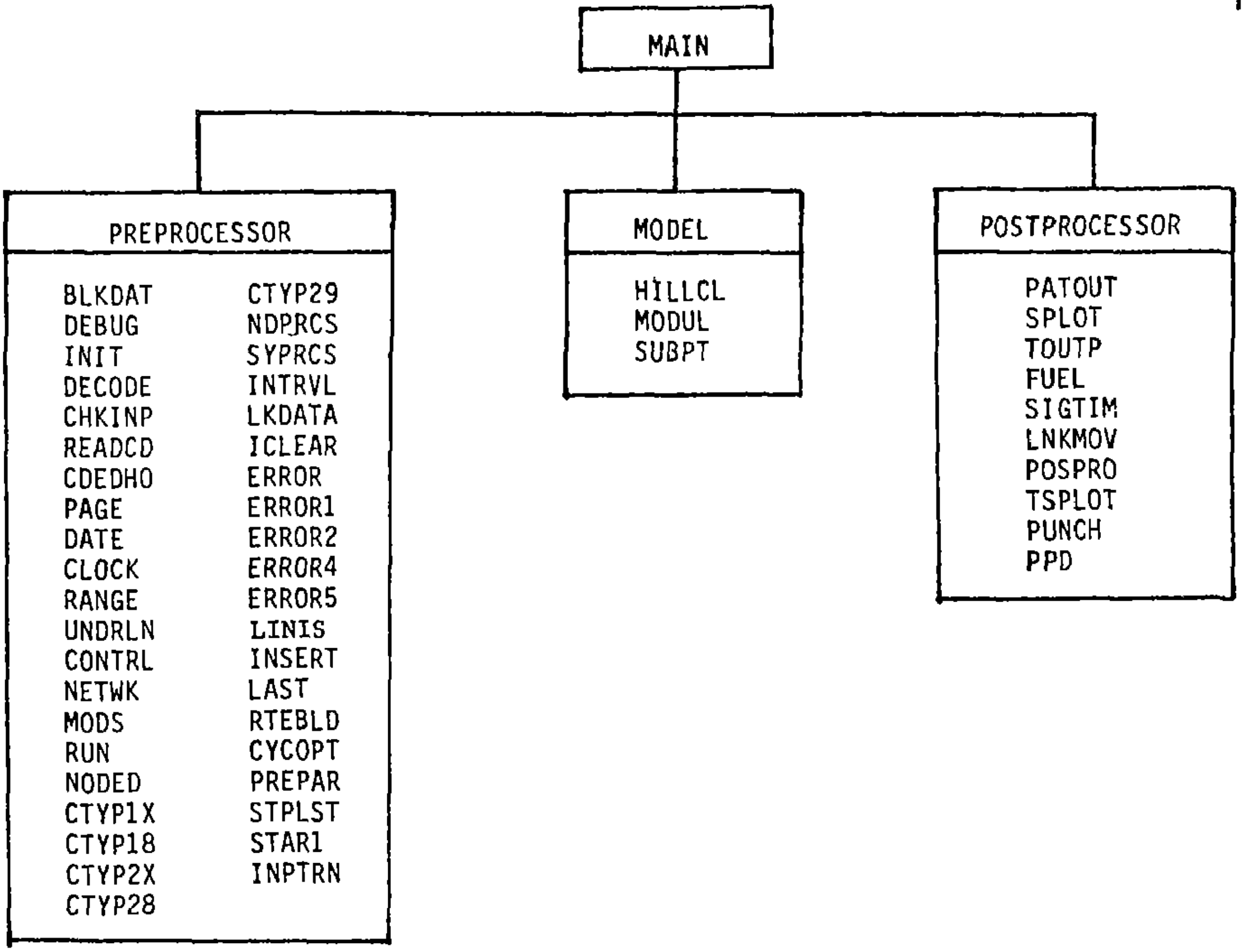


Figure 3.1 TRANSYT-7F FUNCTIONAL PROGRAM STRUCTURE

trees that determine the order in which the links are to be optimized. The third function of the preprocessor is to generate, initial signal timing phase lengths if they were not supplied by the user.

Model: This section which is the main section of TRANSYT program contains the traffic simulation submodel (SUBPT), the optimization submodel (HILLCL), and a support routine (MODUL).

The sequence of events for an optimization run is as follows:

1. An initial timings plan is input by the user, or the program generates initial offsets and phase lengths if requested by user.

2. Subroutine SUBPT simulates traffic flow and calculates the performance index (PI) for the initial timing plan.

3. Subroutine HILLCL varies the offset at the first signal and calls SUBPT to recalculate the network PI. It will continue to vary the offset at this signal as long as the PI is reduced.

4. The model proceeds sequentially through all the signals for all the variations of the offsets and phase lengths input, attempting to locate minimum PI.

Post Processor: The primary function of the post processor is to output the results. The outputs includes the performance (P.T.), stop line flow profile plots, signal controller timings settings and time space diagrams.

TRANSYT-7F functional program structure is as shown in Fig. 3.1.

3.2 BASIC APPROACH:

3.2.1 TRAFFIC FLOW MODEL:

The most important aspect of the simulation of traffic along the signalized streets is the manner in which the traffic flow is modelled.Consider a single lane of traffic with a standing queue at the intersection waiting for the green display Following the phase change to green for this link, there is a slight delay before the driver of the first vehicle reacts and crosses the stop line. This is the start up lost time. After several vehicles have crossed the stop line usually three, the queue begins to discharge at a essentially constrant rate. This is the saturation flow rate. This is illustrated in Fig. 3.2. In the upper part of the figure, the vehicle trajectories depicts the vehicles location in time and space. All the vehicles are stationery until a time t_1, when green display occurs. The start up lost time is L, after which the vehicles cross the stop line.

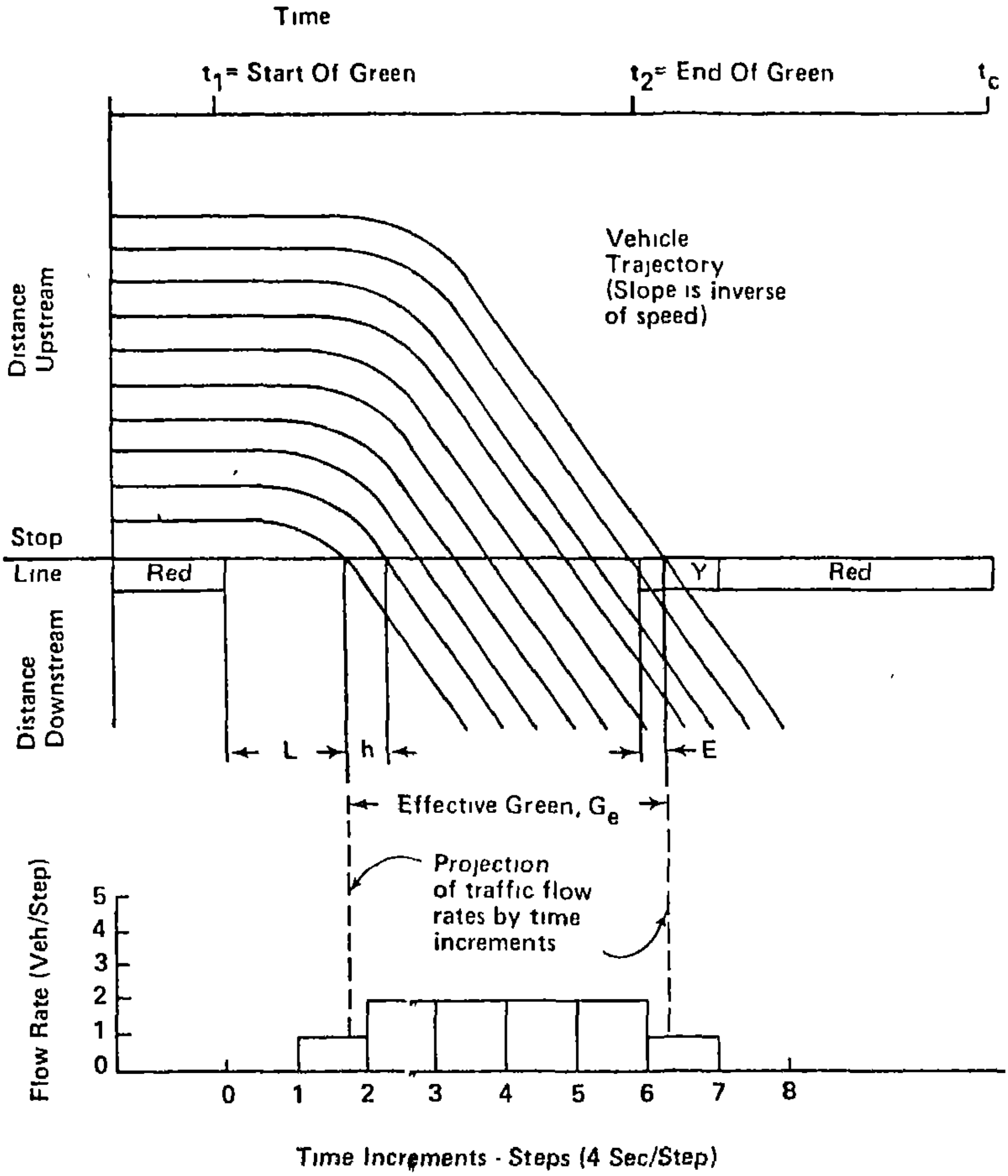
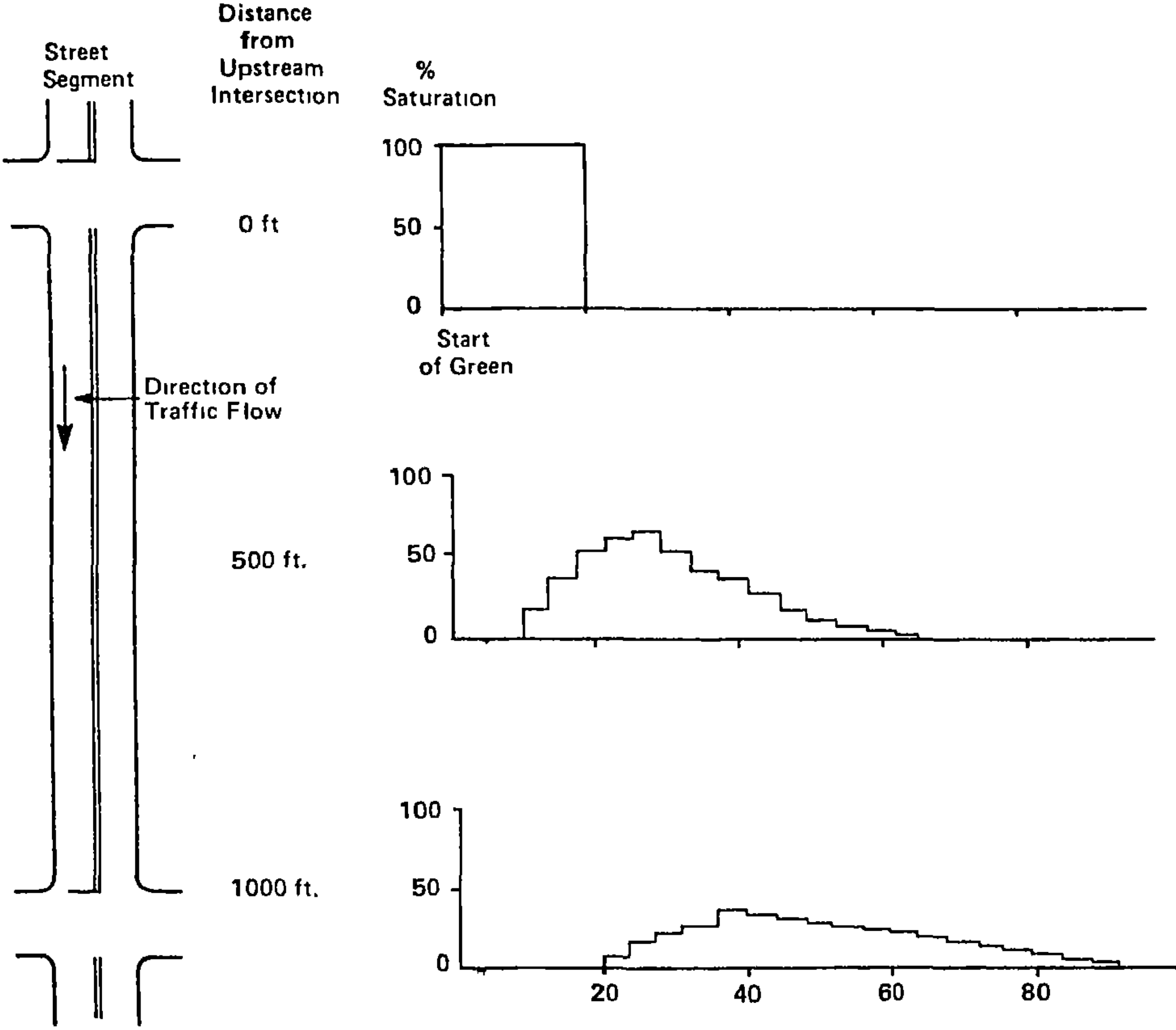


FIGURE 3.2 SIMPLIFIED REPRESENTATION OF TRAFFIC FLOW FROM A STOPPED QUEUE



Source. Reference [23]

FIGURE 3.3: SIMPLE CASE OF PLATOON DISPERSION

Once the signal changes from yellow to green, still some vehicles continue to pass through the intersection. This utilization of clearance interval is the extension of the effective green time known as 'E'. Thus the effective green time is the green time minus the start-up lost time and extension into the effective green.

When the effective green time is divided into start, equal intervals of time known as steps, the number of vehicles crossing the stop line in each step, is the flow rate in vehicles per step. The vehicle crossing times at the stop line are projected to the lower part of the figure, and the flow rate in vehicles per stop is plotted as a histogram. This is the vehicular departure profile. The flow rate will be rectangular, and the maximum flow rate when converted into vehicles per hour, gives the saturation flow rate. In reality far fewer vehicles will actually cross the stop line, due to alternating green and red displays, lost time, and usually less demand than capacity.

As a queue becomes a moving platoon it tends to disperse, or spread out, the farther down stream it travels as shown in Fig. 3.3. This is due to tendency of the drivers to maintain safe headways or spacings between vehicles. Because the flow is restricted by the lead vehicle, the platoon disperses back from the lead vehicle. TRANSYT models the dispersion of these platoons as they progress along the link.

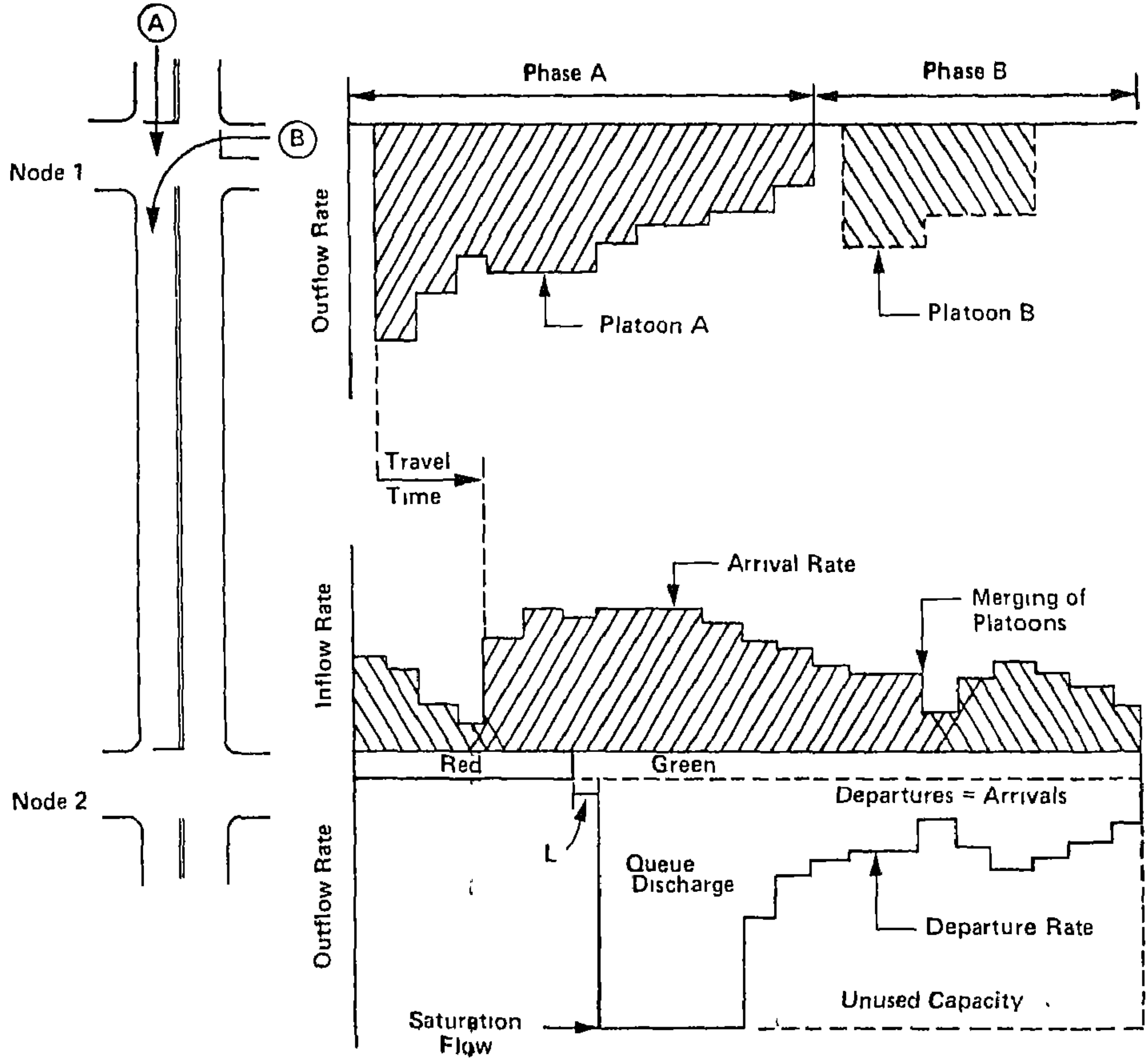


FIGURE 3.4: DISPERSION OF MULTIPLE PLATOONS

For each time interval (step), t, the arrival flow at the down stream stop line is found by

$$q'(t+T) = F \times q_t + [(1-F) \times q'(t+T-1)]$$

where,

$q'(t+T)$ = predicted flow rate in time interval $(t+T)$ of the predicted platoon

q_t = flow rate of the initial platoon during step 't'

T = 0.8 times the free travel time on the link

F = a smoothing factor where,

$$F = \frac{1}{1 + T\alpha}$$

'α' is a empirically derived constant, called the platoon dispersion factor.

This PDF will vary to consider site specific factors such as grades, curvature, parking, opposing flow interference and other sources of impedance. The default value taken by program is 0.35, which has been found by researcher, to best represent measured dispersion on typical urban streets.

The interaction of arrivals and departures is as shown in Fig. 3.4. Platoon A disperses and merges with platoon B showing multiple dispersions of platoons. The upper profile at node 2 is the arrival pattern on the incoming link at this node. The lower profile at node2is the departure pattern of

the out going link at this node. With phase time of node 2 added to profiles, a queue builds up until the onset of green for the incoming link. After a short period of start up lost time, the queue discharges at saturation flow rate until it is discharged completely. There after for the remaining duration of the effective green, the departure profile is a mirror image of the arrival profile, as would be expected. The blank area between the histogram and dashed line represents the unused capacity. The above series of examples demonstrate the traffic modelling concept of TRANSYT-7F.

3.2.2 DELAY AND STOPS:

The delay model of the TRANSYT program is based on the Webster's model. This is a three component model given by

$$D = D_U + D_R + D_S$$

where,
D = total delay
D_U = uniform delay
D_R = random delay
D_S = saturation delay.

The uniform delay component is the delay due to the recurring cyclic demands and stops. It is calculated by averaging queue length over the cycle. Random delay component take care of the delay due to the random arrivals of traffic. The last component, d_s, is an empirically derived adjustment

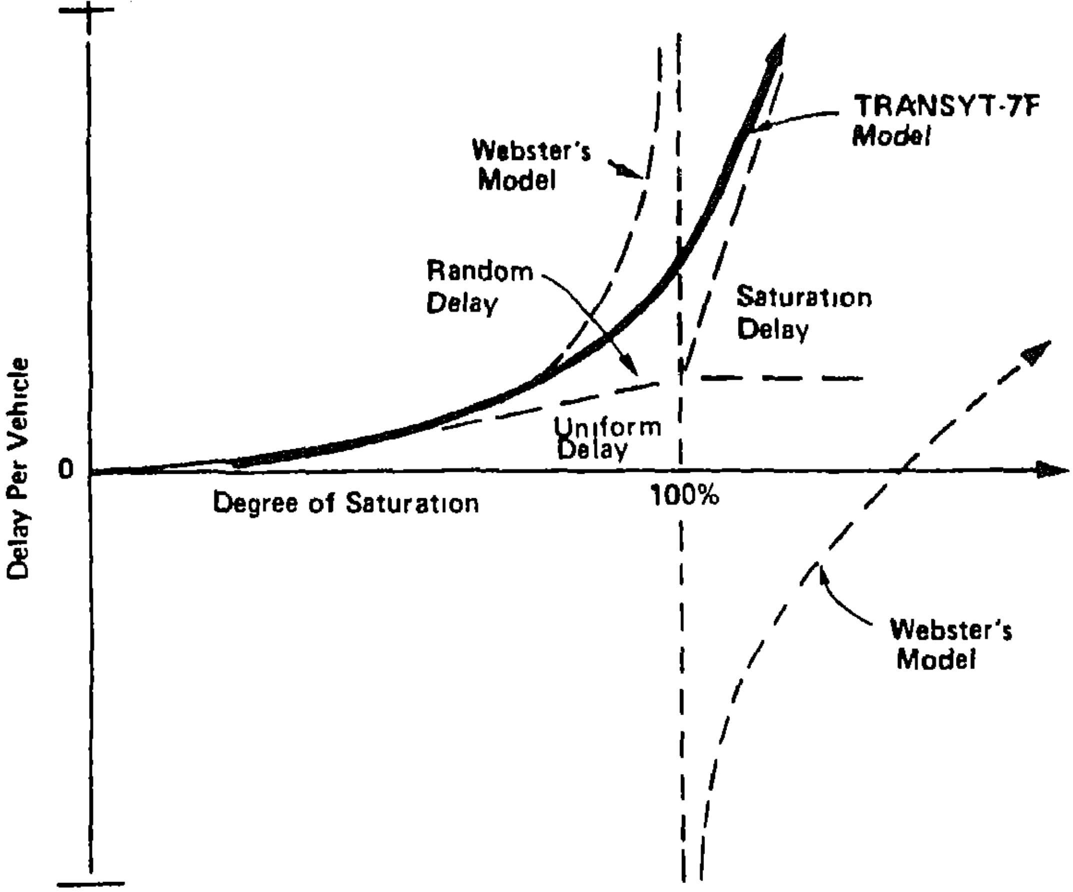


FIGURE 3.5: TRANSYT-7F ESTIMATE OF DELAY

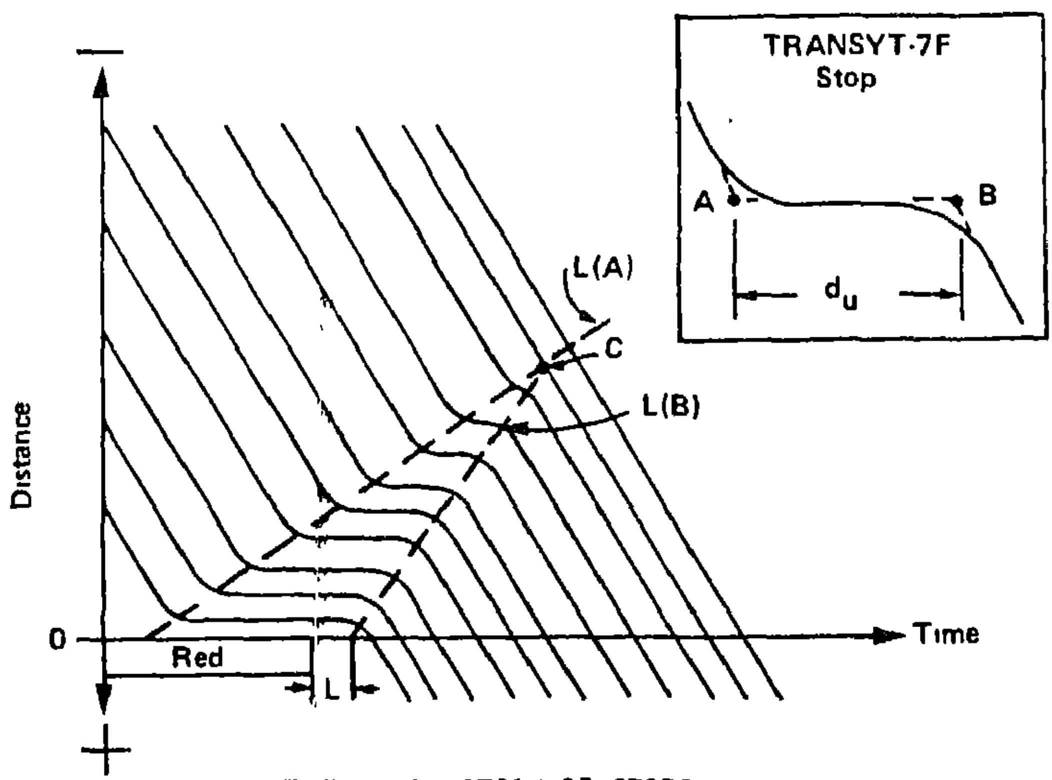


FIGURE 3.5: DERIVATION OF STOPS

which adjusts the sum of the uniform and random elements to confirm more closely to the measured delay. The D_R and D_S components are based on the Webster's model but corrected for the condition when degree of saturation approaches unity. This D_S and D_R components are primarly function of degree of saturation and period length. When the degree of saturation exceeds 1.0 (100 percent) the random and saturation delay increase very rapidly as the period length increases. The TRANSYT-7F estimate of delay stops is as shown in Fig. 3.5.

The number of vehicles stopped is equal to the number of vehicles arriving while a queue is present. If the delay to such vehicles are too small only partial stops are counted. TRANSYT-7F assumes that all the vehicles that are delayed are also stopped. This is not always true but it is done to properly model 'slow downs' when the vehicles actually do not stop. Vehicles would experience 'stops' that might be only speed change cycle, with out complete stops. TRANSYT assumes that such vehicles momentarily stop and calculates the effective stops by filtering algorithm. Studies by TRRL suggest that short periods of delay can be expressed as fractions of stops for the vehicles affected. Empirical studies by TRRL produces the relationship between the percentage of stops and length of delay as shown in Fig. 3.6. TRANSYT-7F has the inbuilt facility to generate this reduction of stops.

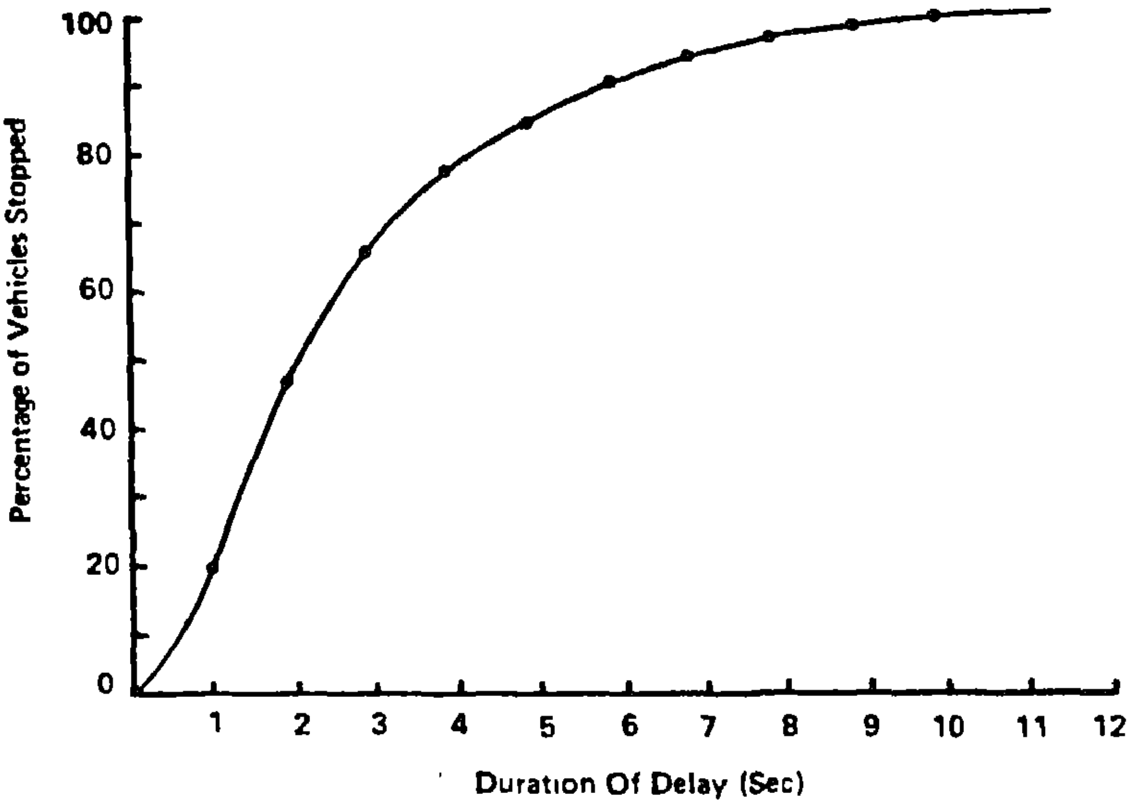


FIGURE 3.6: REDUCTION OF STOPS AS A FUNCTION OF LENGTH OF DELAY

3.2.3 FUEL CONSUMPTION MODEL:

The model predicts the fuel consumption based on the measures of effectiveness produced by TRANSYT simulation model. The model is

$$F = K_1\ TT + K_2\ D + K_3\ S$$

where,

F = fuel consumed in Litres/hour

TT = total travel in veh-km/hour

D = total delay in vehicle-hours/hour

S = total stops, in stops per hour

K_i = co-efficients of regression, which are functions of free speed.

The parameters of TRANSYT-7F fuel model were estimated from experiment studies under typical urban conditions. The resultant data were analyzed by step wise multiple regression and the model resulted.

The limitations of the model are

1. The model parameters were determined from studies conducted with only one test vehicle but the model co-efficients were adjusted to be representative of average vehicles.
2. No explicit consideration was given to factors such as congestion, vehicle mix, geometric environmental factors such as road gradient, curvature surface quality, temperature and other factors.

3.3 TRAFFIC SIGNAL TIMING:

3.3.1 INTRODUCTION:

The network of streets and intersection is represented by a node/link identification scheme in TRANSYT-7F. A node is an intersection and a link is an uni directional section of road way connecting two nodes. TRANSYT-7F can analyse a network of 50 intersections and 250 links in a single run.

TRANSYT-7F only deals with pretimed control. Cycle lengths varying from 30 sec. to 300 secs. can be input and it has the capability of evaluating a range of cycle lengths and selecting the best cycle length for the network. TRANSYT-7F allows for a double cycled signals, where given controllers operate on a 'cycle' that is one half of the system cycle length. In TRANSYT-7F a maximum number of 7 phases, can be tried out in a single cycle, 6 being vehicular traffic phases and an optional pedestrian phase being the 7th . Various phase sequences may be tried out but the phase sequence for each tried run is a user input and no default value is generated.

The offset is normally a time from a system reference point to the begining of the cycle at each of the signal controllers in the system. Offsets are generally determined so that, to the extent possible traffic can flow through a number of signals without stopping. TRANSYT-7F can explicitly optimize offsets and phase lengths for a given cycle length.

3.3.2 PERFORMANCE INDEX:

While optimizing TRANSYT-7F minimises an objective function called the performance index (PI). The PI is a linear combination of delay and stops and is expressed as follows

$$PI = \sum_{i=1}^{n} (d_i + K S_i)$$

where,

d_i = delay on link i (n links) in veh-hrs.

S_i = stop on link i in stops/sec.

K = a user input co-efficient to express the importance of stops vehicle to delay.

Values of 'K' between 20 to 50 have shown to produce a good balance between stops and delay and tend to minimise fuel consumption.

3.3.3 OPTIMIZATION:

As discussed earlier TRANSYT-7F can explicitly optimize phase length or offsets which ever is specified or both in a given single run. The optimization technique used in TRANSYT-7F is referred to as a 'Hill-climbing' technique. This is an iterative, gradient search technique that requires extensive numerical computations by the computer.

The following steps are followed for offset optimization:

1. An initial signal timing plan is simulated by TRANSYT-7F traffic model and the initial PI is calculated.

2. At signal 'i', the offset is increased by an amount specified on the optimization step size list input by the user (or) generated on its own by TRANSYT-7F. The resulting traffic flows are re-simulated on down stream links, subject to the sensitivity parameter threshold values, and a new PI is calculated.

3. The new PI is compared with the previous value (i.e. before the last signal timing change) as follows:
   a) If the new PI is less than the previous value, the program continues to increase the offset by the same amount, as long as the PI continues to decrease. When the PI again increases, the program goes to step 4.
   b) If the new PI is greater than the previous value, the program will decrease the offset by the same amount and continue to decrease the offset by this amount as long as the PI continues to decrease. When the PI again increases, the program goes to step 4.

4. When no further improvement is made varying the offsets at the signal, the model goes to the next signal and begins at step 2 with same optimization step size. Changes in the offset are examined at each signal in the network in turn for the same optimization 'step size'.

5. Steps 2 to 4 are repeated for all the optimization step sizes specified.

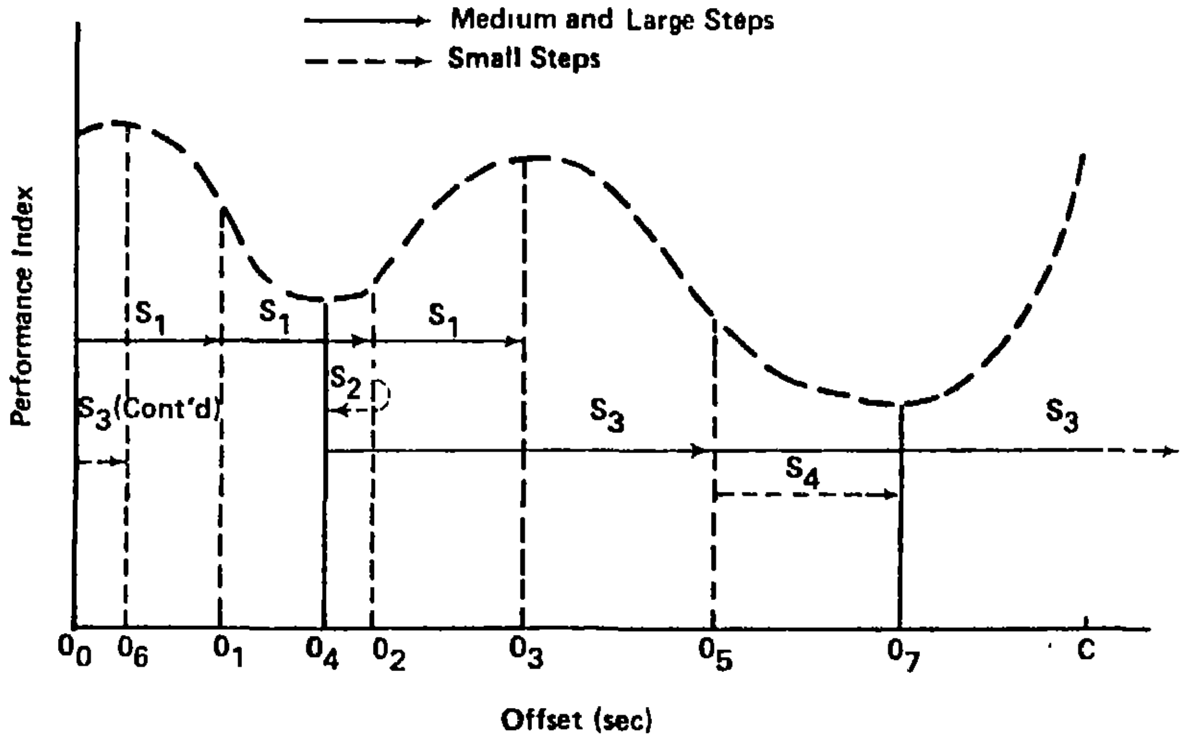


FIGURE 3.7 ILLUSTRATION OF THE HILL-CLIMB PROCESS

The concept of optimization step size is best explained here in the following example. The step sizes are as shown in Fig. 3.7 being S_1, S_2, S_3, S_4. This is the list of optimization step sizes. For the first step of the hill climbing process, S_1, change in offset is a medium sized step of about 15 percent of the cycle. This changes the offset from the initial offset of zero to O_1. The PI is clearly lower, so O_1 is better. Add S_1 again, which has the same result, so O_2 is the new offset. Adding S_1 again results in an offset of O_3, but here the PI increases, so the 'best' offset thus far is O_2.

Let the next offset step size, S_2, be small, say one second. When S_2 is added to O_2, the PI increases, so the direction is reversed. Clearly the offset will continue to 'improve' until the valley of the curve at O_4 is eventually found. This is the 'best' solution thus far, but is not clearly the optimal solution.

Next, use a large offset step size, or about 40 percent of the cycle, S_3. The PI at the resulting offset, O_5 is lower than before, so the search has 'escaped' from the 'local' minimum. Adding S_3 would get the search back into the first peak of O_6, so O_5 is retained.

Finally repeat the series of small step size searches using S_4, and the best solution will be eventually found at O_7. Although the 'best' solution is found in this example it is

not so always. However TRANSYT-7F always produces a good signal timing plan.

3.3.4 CYCLE LENGTH SELECTION:

Cycle length selection can be automatically accomplished in TRANSYT-7F. If the minimum and the maximum limits of the cycle length and a cycle length increment are input, the TRANSYT-7F optimizes offsets and phase length as described earlier for each and every cycle length between the minimum and the maximum levels at the levels of increment and selects the best cycle length, that being the one with least value of PI.

3.3.5 MERITS AND DEMERITS:

TRANSYT-7F is one of the most popular models currently in use almost through out the world, in developing optimal signal timings plan for an urban road network.

The popularity of it is attributed to its success in effectively optimizing signal timings plans, resulting in improved traffic flow and also reduction in stops, delay and fuel consumption.

TRANSYT-7F can be used to check the performance of the existing signal timings plan by making a simulation run. Also at the same time a alternative optimal timings plan can be developed by making simulation and optimization run. One more feature is its flexibility to analyse various phase sequences, cycle lengths or geometric configurations. According to reports [Traffic Engineering and Control - October 1985]

available from the survey conducted through out the world, on the usage on TRANSYT-7F, optimal signal timings plan developed using TRANSYT-7F reduced stops and delays to a appreciable extent. This meant reduction of travel time through out the system and hence the fuel consumption.

One more excellent feature of TRANSYT-7F is the clarity of the program, especially the outputs, giving performance tables and signal controller timing tables.

Regarding the demerits, according to the reports available (Traffic Engg. and Control, Oct. 1985) from the survey, on the usage of TRANSYT-7F, the biggest problem has been the difficulty in collecting the excessive amount of data required by the program. Coding such data is a tedious and error prone process.

Also the program requires large memory and computer time and in making several runs, which is quite common, results in a very costly affair.

Inspite of the above draw backs it can be said that, it is the most successful computer model available at present for designing signal timings plan for urban road network, and hence used for the present work.

CHAPTER 4

PERFORMANCE STUDY OF INTERSECTIONS

4.1 SCOPE OF STUDY:

In the present study it is planned to analyse the performance of the signalized co-ordinated fixed time control intersections for various conditions of flow of traffic on urban roads, as predicted by the TRANSYT-7F Model. In order to evaluate the performance of the model for various flow parameters such as volume of traffic approach speed, intersection spacing, cycle length etc. a sensitivity test, is performed considering two case studies. An urban consider with three coordinated signalized intersections is considered in the first case study where as in the second case study a higher magnitude problem i.e. a typical urban corridor with six coordinated signalized intersections is considered. In view of the large input required by the program a user friendly interactive program has been developed for the entire input data of TRANSYT-7F.

4.2 IMPLEMENTATION OF TRANSYT-7F:

In order to implement the TRANSYT-7F program (version 2.0, Release 1984) on the DEC-1090 computer system, certain modifications had to be made to the program to suit the DEC FORTRAN COMPILER. The TRANSYT program initially written in Ansi FORTRAN 66 has some FORTRAN-77 features in its latest release. Since the DEC system here at the computer centre has no FORTRAN-77 compiler, all the character statements had to be modified to suit the available FORTRAN-IV COMPILER.

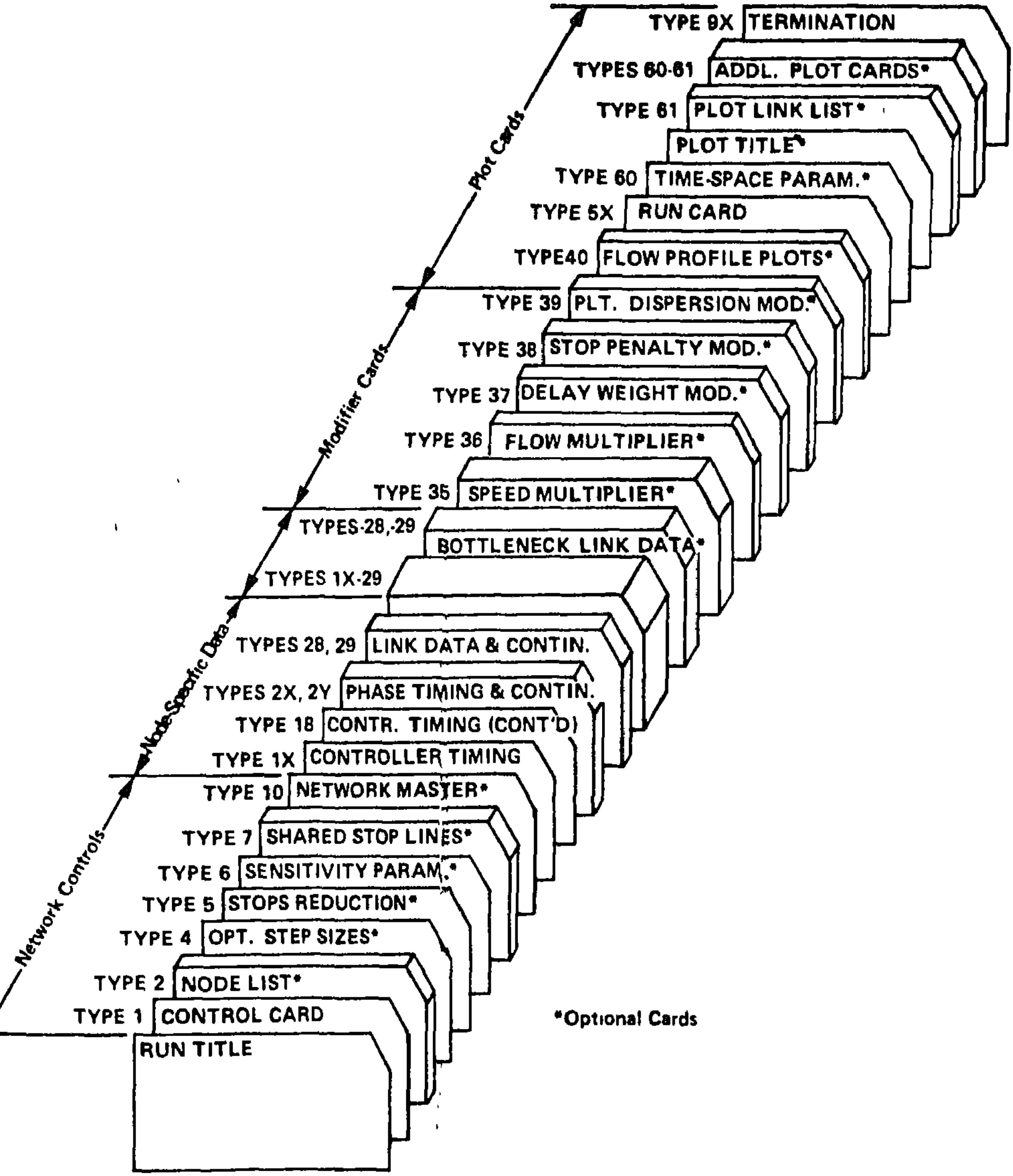


FIGURE 4.1: TRANSYT-7F DATA DECK STACK

Also the entire structure of the read statements had to be modified through out the program. After the above modifications the program is run and checked against inputs and outputs supplied along with the program.

4.3 INTERACTIVE INPUT PROGRAM:

The large input data requirements of TRANSYT program makes the coding of the necessary input data a cumbersome and error prone process. The TRANSYT-7F input data deck is as shown in Figure 4.1. For every run a maximum possible 24 types of cards, and on each card sixteen data fields or items can be input. Some of the cards are compulsory and the others optional. A self explanatory user friendly interactive program has been developed to code the input data, and to make the user understand the various input variables required by the program. Also the program requires the user to input the data in the following fixed order.

- Run Title Cards
- Network Control Data Cards
- Node Specific Data Cards
- Modifier Cards
- Plot cards
- Run Termination Card

The program developed takes care to see that data is input in the above order. The interactive program also apprises the user of the flexibilities offered by the program

in making various types of runs such as the simulation runs, optimization runs, input data check runs etc. and also the unique facilities offered by the program in the form of modifier input cards.

The program also gives the user an idea of the range of values of various variables used by program and then default values , when input is ignored, wherevever necessary. The main aim of the program is to enable the strange user to understand the details and coding requirements of input variables sitting sight before the computer terminal, saving him the time of going through the manual for each and every minute detail. The structure of the program is briefly described below in the following steps:

(1) First of all an explanation of the card type and type of data to be input are given.

(2) If the card is optional the choice of usage is given to the user, and if compulsory the program asks for input before proceeding further.

(3) Explanation of each variable in each card, their range and default values, are also mentioned, while receiving the input of the variable.

(4) The program writes the data so input on the terminal in a free format, in a fixed formatted out put file which is linked to the main program, the TRANSYT-7F, while executing it.

The interactive program is around 1300 lines of code which gives an idea of the enormity of input required by the TRANSYT-7F program for each run. A sample of the explanation given and input asked, while in execution i.e. on the terminal put put, is as shown in Appendix-A.

4.4 CASE STUDY - I :

4.4.1 DESCRIPTION:

The purpose of the present study is to analyse traffic flow performance characteristics of coordinated fixed time control intersections by using the TRANSYT-7F model, and testing its sensitivity for various flow conditions of traffic on urban roads. The road data and the traffic data are all assumed and no actual field study has been done to determine them. But the data are so assumed so as to represent actual road and traffic flow conditions on the field.

In the present problem a busy urban corridor with three coordinated signalized intersections is considered. The major and the minor corridors are both of 4 lanes each, two lanes serving for traffic in each direction. A three phase fixed time signal control is considered at each of intersections. The following parameters of traffic flow which are inputs to the TRANSYT-7F model, are iddentified for performing sensitivity analysis, to study their impact on the performance of intersections as evaluated by the model.

TABLE 4.1 : DETAILS OF INPUT DATA- SENSITIVITY ANALYSIS - CASE STUDY - I

Sensitivity Analysis Parameter Under Study	Range of Variation	Step size for Every TRANSYT Run	Constant Values of Parameters of Traffic Flo for Present Study			
			Speed kmph	Link Length (m)	PDF	Volume of Traffic. V
Cycle Length Seconds	45-70	5	30	500	0.35	500
Volume of Traffic VPH			Speed kmph	Link Length in (m)	PDF	Cycle Len (sec)
	200-800	100	30	500	0.35	Best
Speed of Flow KMPH			Volume of (VPH) Traffic	Link Length (m)	PDF	Cycle Ler (sec)
	25-50	5	500	500	0.35	Best
Link Length of Corridor (m)			Speed KMPH	Volume of Traffic. VPH	PDF	Cycle Ler (Sec)
	250-1500	250	30	500	0.35	Best
PDF Value Input			Speed KMPH	Link Length (m)	Volume of Traffic VPH	Cycle Le (Sec)
	0.25, 0.35 and 0.50	-	30	500	500	Best

They are,

- Signal cycle length
- Volume of Traffic Flow
- Approach Speed
- Spacing of Intersections (Link Length)
- Platoon dispersion factor (PDF).

The impact of cycle length on the performance of signalized intersections, as determined by the TRANSYT-7F model is studied at flow level of 500 VPH, speed of flow of 30 kmph, link length or intersection spacing of 500 m and PDF values of 0.35. The signal cycle length is varied from 45 seconds to 70 seconds with a step increase of 5 secs. for every TRANSYT-7F run. The variations in the measures of effectiveness (MOE) such as average delay, percent of vehicles stopped per hour, performance index , average speed of travel of vehicles in network, fuel consumption that determine the performance of the intersection are studied.

Similarly TRANSYT-7F runs are made to test the sensitivity of the model for varying conditions of flow level, approach speed, link length and PDF. Each time one of the above parameters is varied with a step increase in every run, for particular flow values of other parameters as clearly indicated in Table 4.1. In each of the above runs the best cycle length is evaluated in the range 40-70 secs , with a step size of 5 secs, for that particular value of the varying parameter under study. In all the above cases graphs are

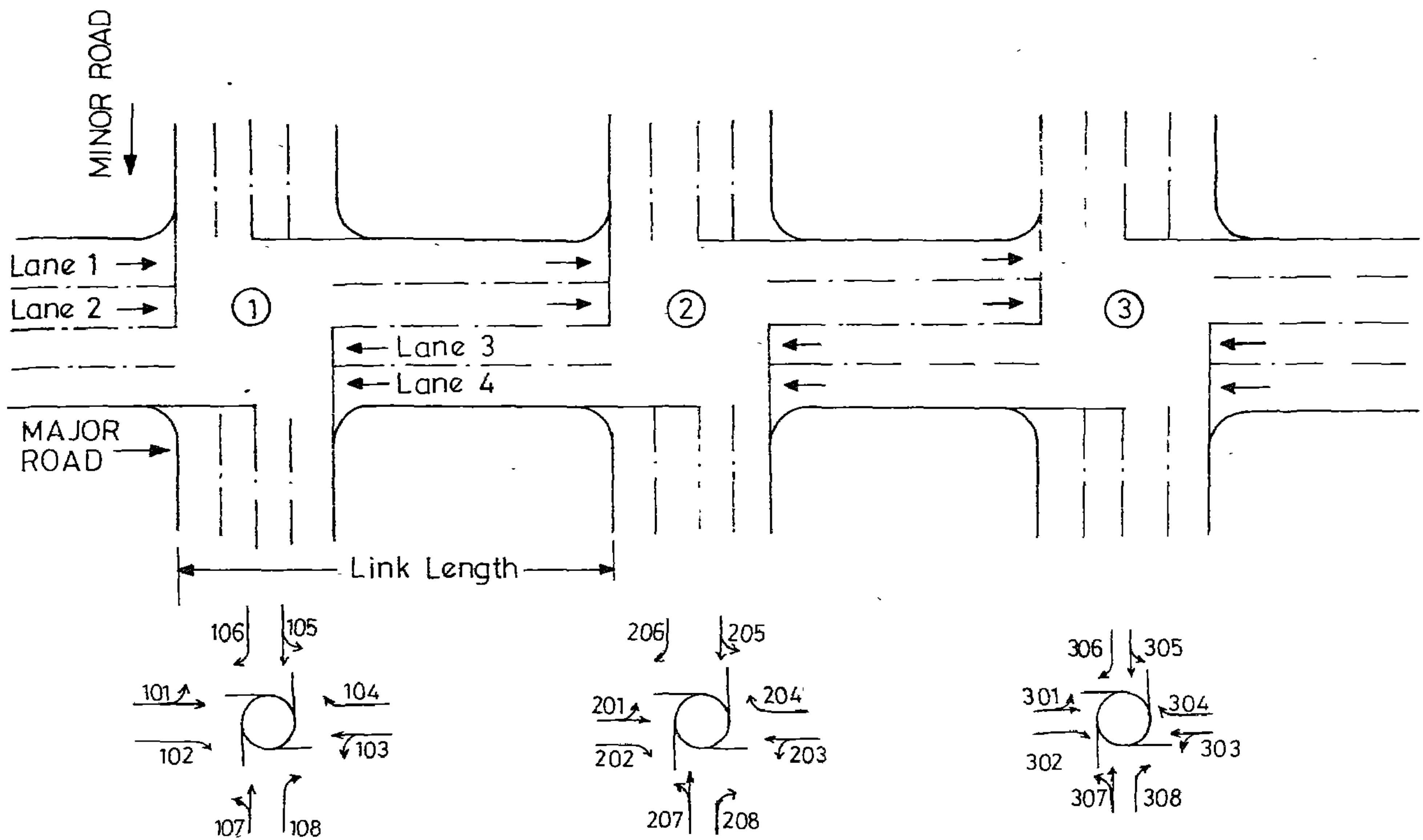


FIG.4·2 LAYOUT OF THREE INTERSECTION CORRIDOR

plotted, between the parameter of interest under sensitive study and the various MOE, and the effects are analysed regarding the behaviour of the model in predicting the intersection performance.

4.4.2 <u>INPUTS</u>:

The inputs for the TRANSYT-7F model fall into four general categories as given below:

- Network data
- Signal timing parameters
- Geometric and traffic data
- Control data and parameters.

<u>Network data</u>: These data describe the network in terms of intersections (nodes) and links (streets). The entire corridor is precoded into a system of nodes and links.

In the present case study the corridor with three intersections of major and minor streets is divided into a system of 3 nodes in all and 8 links at each intersection. One link is assigned for through movement of traffic and left turning traffic and another link for right turning traffic seperately in each direction of traffic. The nomenclature used in numbering the links at intersections is as shown in the Fig. 4.2.

<u>Signal timing parameters</u>: Traffic signal timing parameters are cycle length, phase length, phase sequence, minimum phase durations and offsets.

In the sensitivity analysis conducted on all the parameters, cycle length between 35-70 secs are input, so that cycle evaluation is done for cycle lengths in that range, with an increase of 5 secs each time. The start up lost time and extension of effective green input are 4 secs and 3 secs respectively, representing conditions of traffic in which, drivers avoid fast starts and close headways.

A 3-phase signal control is chosen at each of intersections. The right of way for movement of traffic is along links 101 and 103 during Phase-1. During phase-2 and phase - 3 it is along links 105, 106, 107, 108 and 102 and 104 respectively. An all red interval of 5 secs is also provided for pedestrian crossing of traffic during each cycle length. A minimum phase length of 15 secs for phase -1 and 10 secs for phase - 2 and phase - 3 is only provided and the final settings are calculated by TRANSYT-7F for the best cycle length.

Geometric and traffic data: These data include the link lengths, saturation flows, approach speeds and traffic volumes.

The link length input in this case study varies from 250 m to 1500 m at steps of 250 m during various runs. This is because in urban cities in India the spacing is usually in this range and more so on the lower side of it. The link length of minor street is 250 m always.

The saturation flows input are 1700 veh/lane for through moving traffic, and 1600 veh/lane for turning traffic,

TABLE 4.2 : SIGNIFICANCE OF PDF VALUE

Value	Roadway Characteristics	Description of Conditions
0.5	Heavy friction	Combination of parking,moderate to heavy turns, moderate to heavy pedestrian traffic, narrow lane width. Traffic flow typical of urban CBD
0.35	Moderate friction	Light turning traffic, light pedestrain traffic, 11 to 12 foot (3.4 - to 3.6 meter) lane, possibly divided. Typical of well-designed CBD arterial.
0.25	Low friction	No parking, divided, turning provisions 12-foot (3.6-meter) lane width. Suburban high type arterial.

to simulate the normal average drivers pattern. This is taken from TRANSYT-7F users manual (FHWA, U.S.A., 1981). The volume of traffic in each direction on major streets input are in the range 200 - 800 veh/hour to represent off peak period, normal and peak period traffic flow conditions. The distribution of traffic over the links of the corridor is done, in such a manner so as to represent real field conditions. The average flow of traffic input is 500 veh/hour. The flow on major street is always twice on that compared to minor street as is considered.

The speed input is in the range 25-50 kmph in the case of speed sensitive study, where as for all other runs it is 30 kmph, which is the average speed expected on Indian urban roads under normal conditions.

The value of stop penalty used in the calculation of PI is 25. This value between 20 and 50 has shown to produce good balance between delay and stops and also minimise fuel consumption according to the experiments conducted as reported in TRANSYT-7F manual. The value of PDF input is 0.25, 0.35 and 0.5 so as to represent, all road characteristics and traffic flow conditions in different runs. The significance of the above PDF values is as shown in Table 4.2.

<u>Control data and parameters</u>: Control data indicate those actions the user desires the program to take. The options chosen are optimization runs, selection of phase length,

cycle evaluation summary, printing of final performance table, metric units, and controller timing data. Also the time-space diagrams and stop line flow profiles are plotted for certain particular flow level, speed etc.

4.4.3 OUTPUT:

The various outputs by TRANSYT-7F are,

- Input data report
- Cycle evaluation summary
- Traffic performance table
- Controller timing data
- Stop line flow profile cards
- Time-space diagrams.

The output of TRANSYT-7F for a particular run with flow level 500 veh/hr, approach speed of 30 kmph spacing between the intersections being 500 m and PDF value of 0.35 is as shown in Appendix B.

Input data report: Input data report shows the input data as they are input, but with appropriate headings to indicate what the data values are as shown in Appendix B , Table B.1.

Cycle evaluation summary: Cycle evaluation summary is output for the cycle length range input i.e. 35-70 secs with a step increase of 5 secs. The best cycle length is chosen on the basis of PI value which is a function of delay and stops. The cycle sensitivity indicates how much the M.O.E's are sensitive to the changes in cycle length over the range of cycle lengths evaluated as shown in Table B.2.

Performance table: A table of measures of effectiveness (MOE) is printed, with the MOE indicated for each link, subtotatled by intersection and aggregated for the entire network. The various important MOE printed are (Table B.2).

- Degree of saturation- percent saturation of each link
- Total travel- the total veh-km per hour of travel
- Delay - uniform, random (plus saturation) and total in terms of veh hours/hr and average delay in seconds per vehicle.
- Uniform stops - stops/hr and percent of vehicles stopped.
- Maximum backup of queue and queue capacity- number of vehicles.
- Fuel consumption - the total number of lit/hour.
- Performance Index - the optimization object value function.

The MOE values produced by the program reflect the signal timing plan developed by the program and the input data. The MOE values relate the signal timing plans effect on the traffic performance on each link of the network.

Controller settings: A completely formatted table of controller timing settings is given for each controller. The format provides for the direct implementation of signal timings on the field. The phase lengths in seconds and percent of cycle and the offset at each of the intersection and the lane given right of way in each of the phases are also very

clearly indicated. The controller setting table for a flow level of 500 veh/hr and speed of 30 kmph is demonstrated in Table B.3.

Stop line flow profile plot:

This prints a histogram of the arrival and departure rates during a signal cycle on a particular link. The plots reflect the arrival and departure rates as a function of effective grain. A flow profile plot at 500 veh/hr flow is shown in Fig. B.1. The symbols used ~~ae~~ 'I','S' and 'O' and they are explained in the Fig. B.1. The maximum flow value plotted is the saturation flow rate. The mean modulus of error (MME) is estimated for each generated plot. The MME is a measure of deviation of arrival flow rate from the average flow rate and is a number between 0.0 and 2.0. A uniform flow would have an MME of zero, while an high MME value would indicate strong platooning of traffic. At high MME value, the coordination of the signal system would be beneficial. The MME values shown in Fig. B.1 are for links 103 and 104, 201 and 202 being 0.39 and 0.29, 0.42 and 0.25. The MME values indicate that flow is almost uniform.

Time space diagram: TRANSYT-7F model produces a time space diagram (Fig. B.2) for any continuous series of links. The offsets reflected in the time-space diagram are referenced to the master controller, at intersection 1 as in the present case. The progression bands can be drawn on time space diagram for progression analysis.

4.5 DISCUSSION OF RESULTS FOR CASE STUDY I:

4.5.1 CYCLE LENGTH:

The cycle length is varied in the range 40-70 seconds with a step increase of 5 seconds for every run where as the flow at 500 VPH, speed at 30 kmph, link length at 500 m and PDF at 0.35 are kept constant in all the runs in this particular case.

Best cycle length: The cycle length is varied and performance index which is the objective function for optimization and is a combination of delay and stops is evaluated for every run. Now as the cycle length is increased from 40 seconds to 70 seconds the average delay decreases from 29.30 secs/veh at 40 seconds cycle length to 15.43 secs/veh at 55 secs and then again increases to 17.89 sec/veh at 70 secs cycle length. The average delay is minimum at 55 secs cycle length as seen from Fig. 4.3 and Table 4.3 where all MOE are tabulated.

TRANSYT-7F also models stops, and every vehicle that gets delayed is assumed to stop, although full stops are not assumed for vehicles encountering smaller delays. Now as seen from graph (Fig. 4.4) the stops decrease as cycle length increase, reach a minimum value and then increase. The minimum value of stops is 67 percent at 55 secs cycle length as seen from graph in Fig. 4.4.

Now the performance index which as seen from graph in Fig.4.5 also decrease as cycle length increases, reaches a minimum value and then starts increasing again.

TABLE 4.3 : PERFORMANCE TABLE - CYCLE LENGTH IMPACT STUDY

Flow level : 500 VPH　　Link Length : 0.5 Km

Speed : 30 KMPH　　PDF : 0.35

Cycle Length Secs	Total Delay Veh-Hr/Hr	Average Delay Sec/Veh	Total Uniform Stops (Percent)	Total Fuel Consumption Lit/Hr	PI	Average Speed KMPH
40	36.23	29.30	80	349.31	60.87	18.86
45	20.00	16.18	76	302.99	43.51	22.62
50	19.24	15.55	68	297.81	40.11	22.84
55	19.08	15.43	67	297.22	39.82	22.88
60	20.07	16.23	68	300.30	41.11	22.60
65	20.57	16.63	69	302.30	41.90	22.47
70	22.12	17.89	66	305.16	42.44	22.05

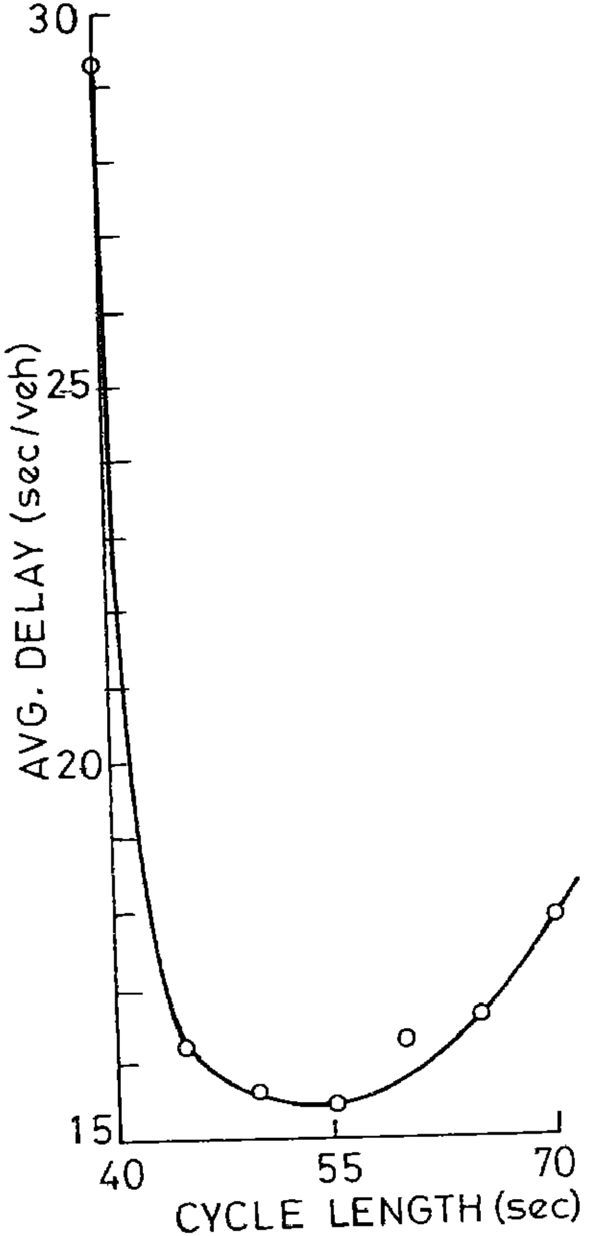


FIG.4·3 AVG. DELALY FOR VARYING CYC LENGTH

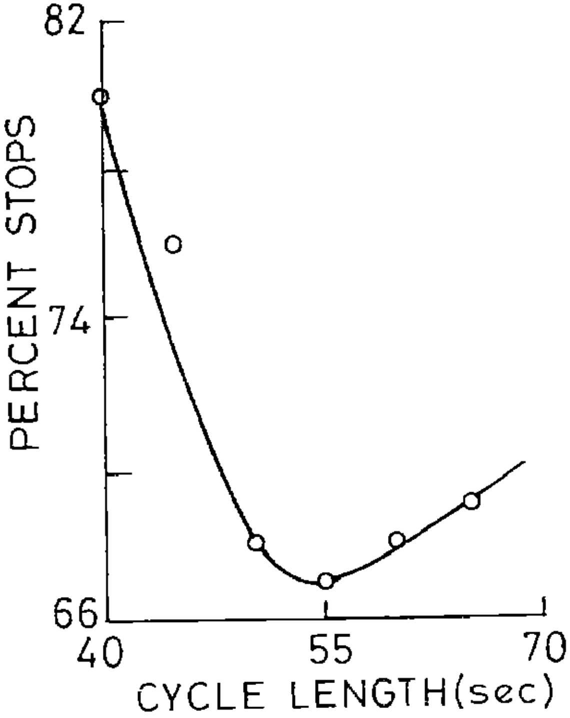


FIG.4·4 PERCENT STOPS FOR VARYIN LENGTH (CYC)

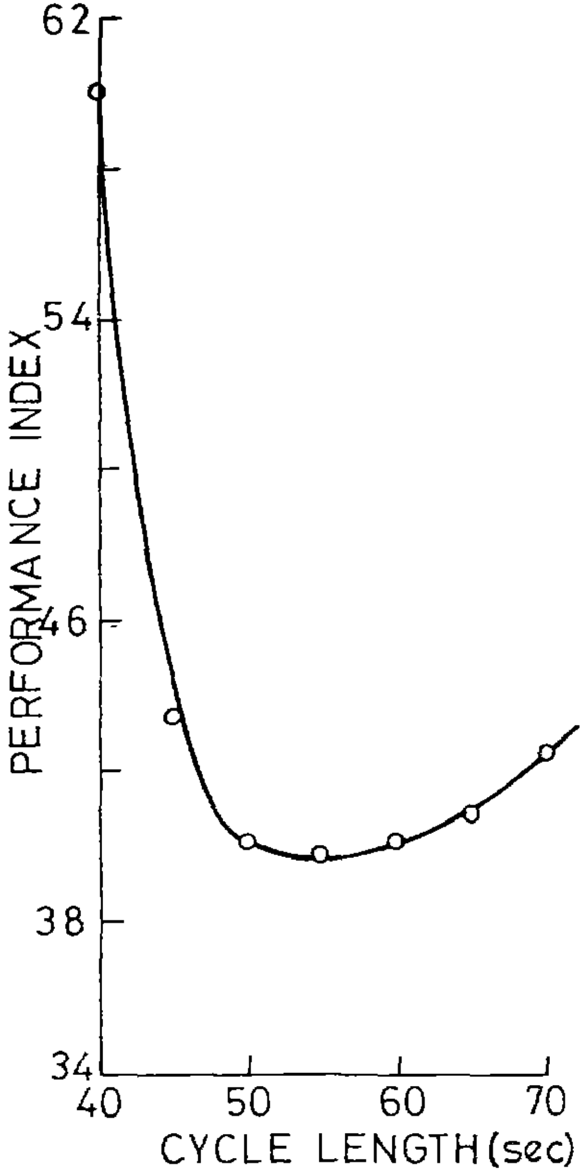


FIG.4·5 PI FOR VARYING CYC LENGTH

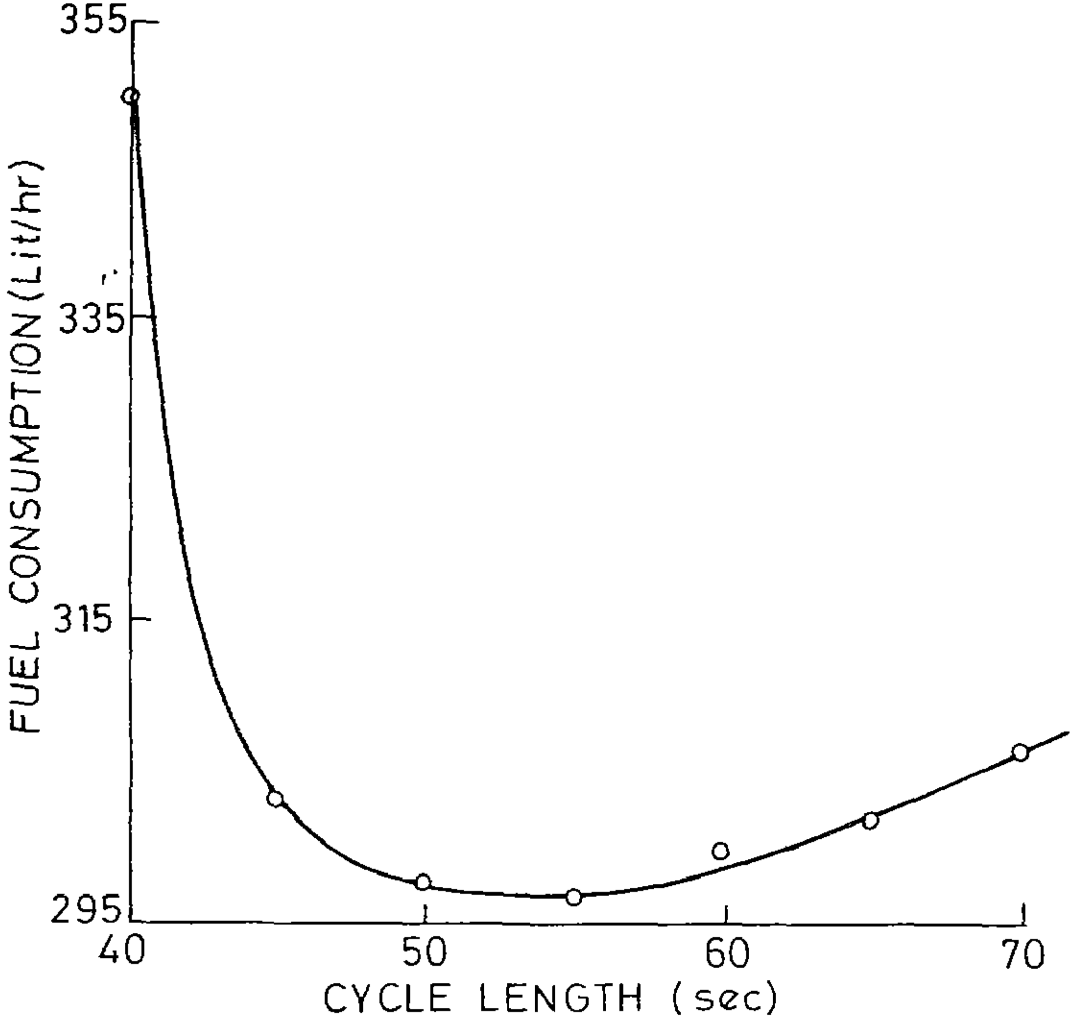


FIG.4·6 FC FOR VARYING CYC LENGTH

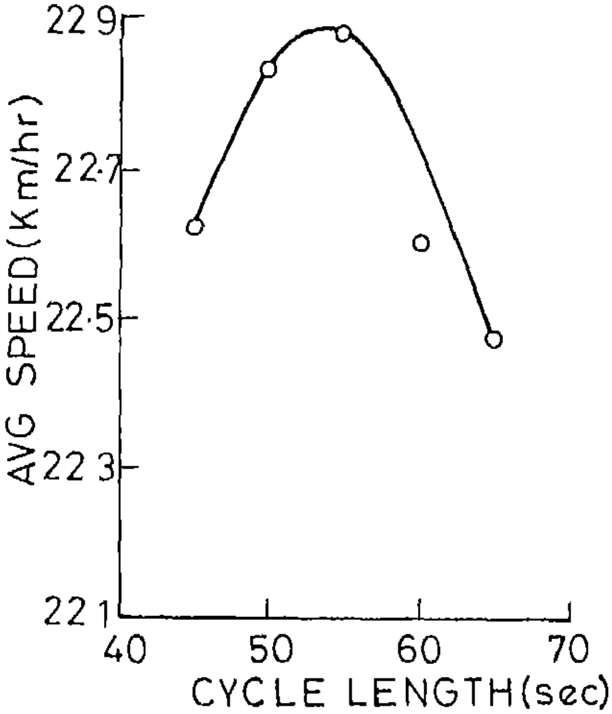


FIG. 4·7 AVG. SPEED FOR VARYING CYC LENGTH

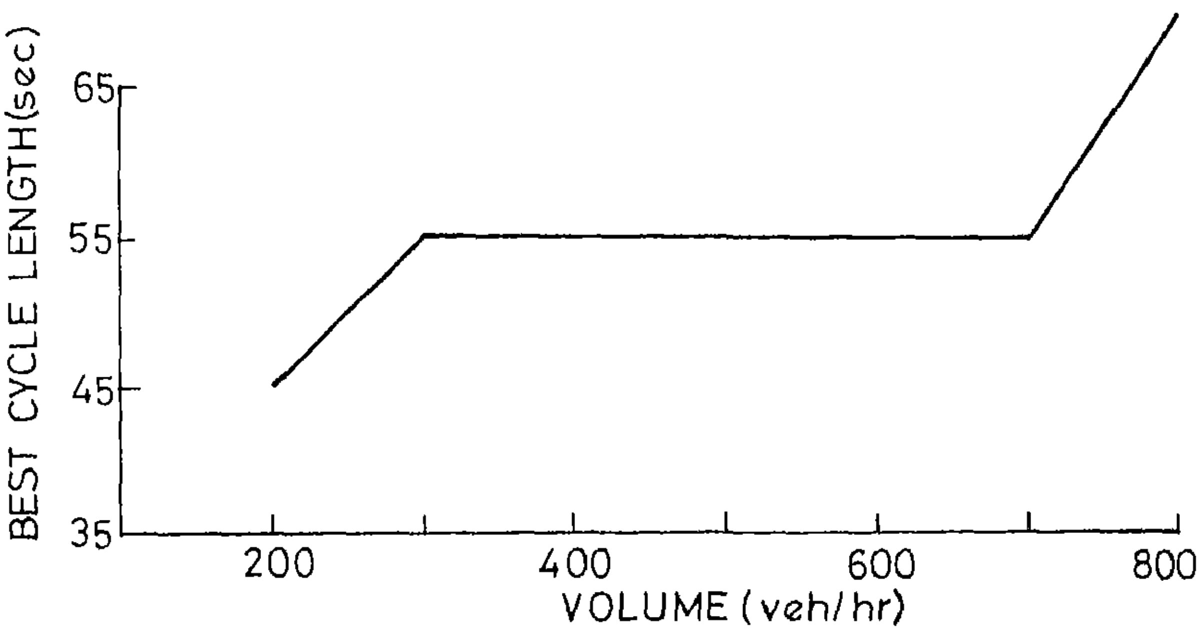


FIG. 4·8 BEST CYCLE LENGTH FOR VARYING FLOW LEVEL

The cycle length for which the PI is minimum is the best cycle length. In this case it is 55 secs at 500 vph and 30 kmph approach speed.

Now as seen from graph (Fig. 4.6) the fuel consumption decreases with increase in cycle length reaches a minimum and then starts increasing again. The fuel consumption is the minimum at 55 secs cycle length i.e. at the best cycle length, being 297.22 lit/hr, as seen from graph.

The average speed of all the vehicles in the network that which is actually possible also follows the same trend i.e. it is the best value or the highest at best cycle length being 22.82 kmph. The average speed increases as cycle length increases until best cycle length and then starts decreasing again as seen from graph in Fig. 4.7.

As seen from above we can conclude that at particular flow conditions the MOE are best at optimum (or) best cycle length.

4.3.2 VOLUME OF TRAFFIC:

Volume is increased from 200 vph to 800 vph in each direction at steps of 100 veh/hour for every run and the other parameters, approach speed, link length and PDF are kept constant at 30 kmph, 500 m and 0.35 respectively. For every particular flow level the cycle length is evaluated in the range 35-70 secs, the best cycle length is chosen and all the MOE evaluated correspond to that cycle length at that flow level. The results are tabulated as shown in Table 4.4.

TABLE 4.4: PERFORMANCE TABLE - VOLUME OF FLOW IMPACT STUDY

Speed : 30 Kmph   Link Length : 500 m

PDF : 0.35

Volume of Traffic VPH	Best Cycle Length Sec	Average Delay Sec/Veh	Total Uniform Stops Stops ./.	Fuel Consumption Lit/Hr	PI	Average Speed Kmph
200	45	10.89	53	112.10	12.13	24.58
300	55	14.15	63	171.37	21.89	23.31
400	55	14.76	65	234.44	30.69	23.11
500	55	15.36	67	297.04	39.78	22.90
600	55	16.20	69	361.57	49.78	22.62
700	55	17.73	71	430.87	61.69	22.11
800	70	20.42	70	507.54	75.48	21.27

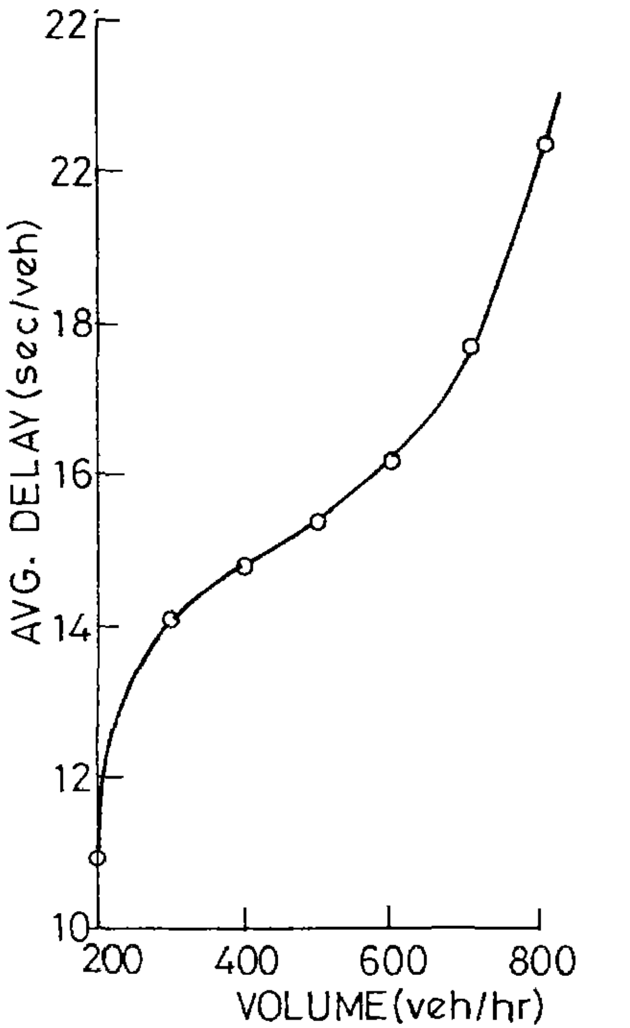


FIG.4·9 AVG. DELAY FOR VARYING FLOW LEVEL

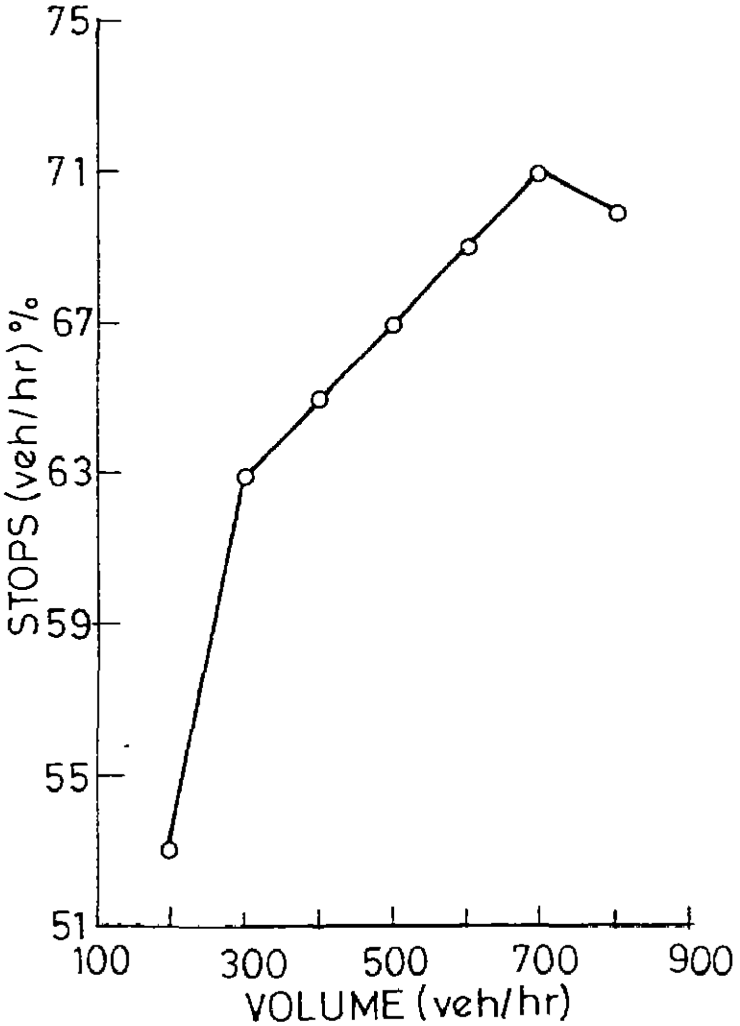


FIG.4·10 STOPS PERCENT FOR VARYING FLOW LEVEL

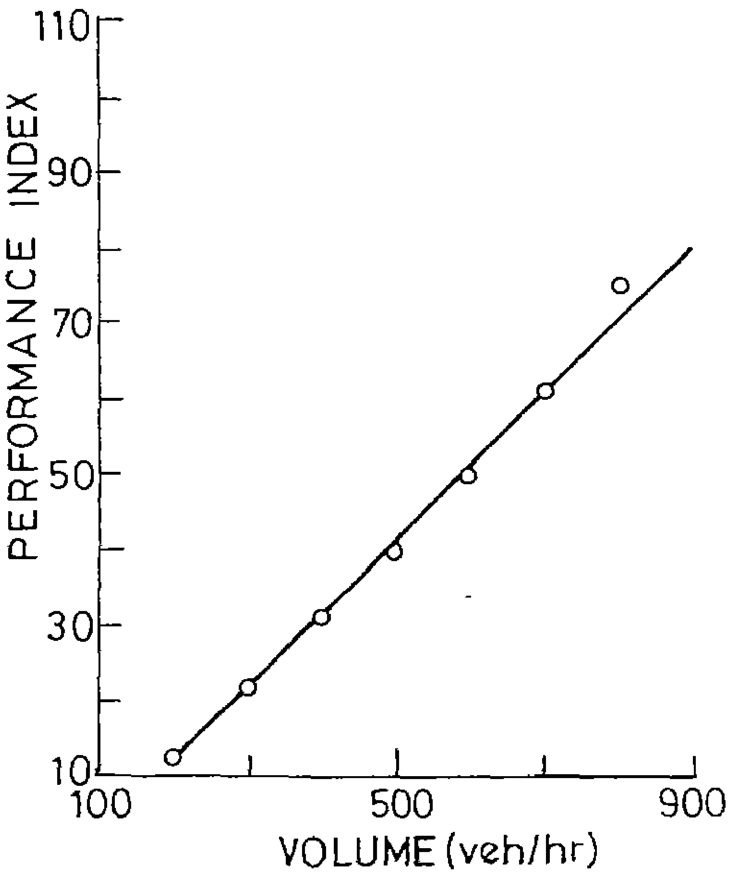


FIG.4·11 PI FOR VARYING FLOW LEVEL

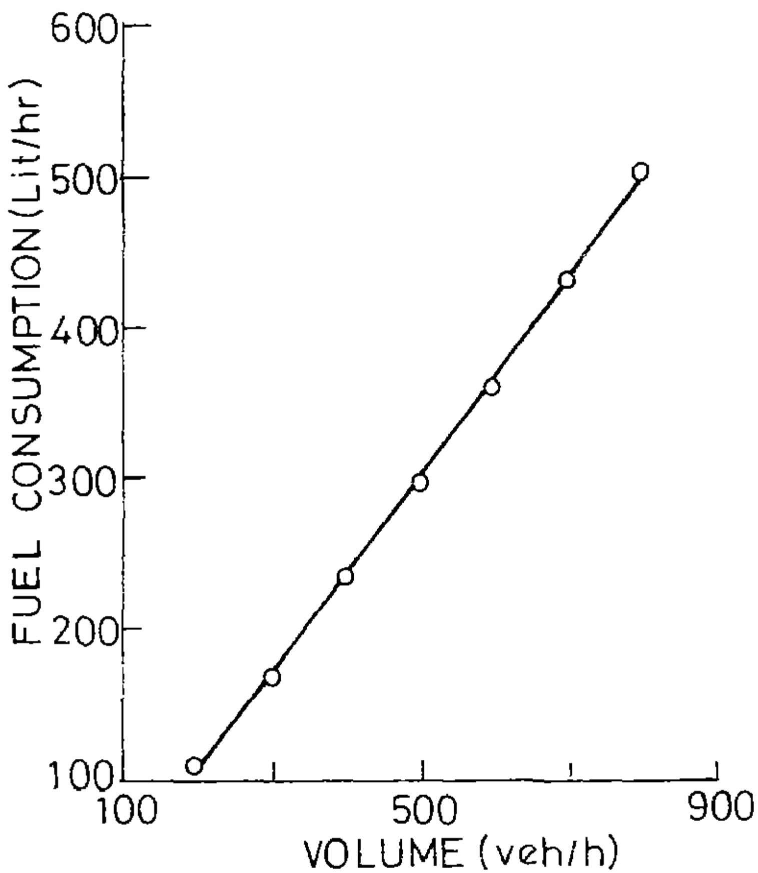


FIG.4·12 FC FOR VARYING VOLUME

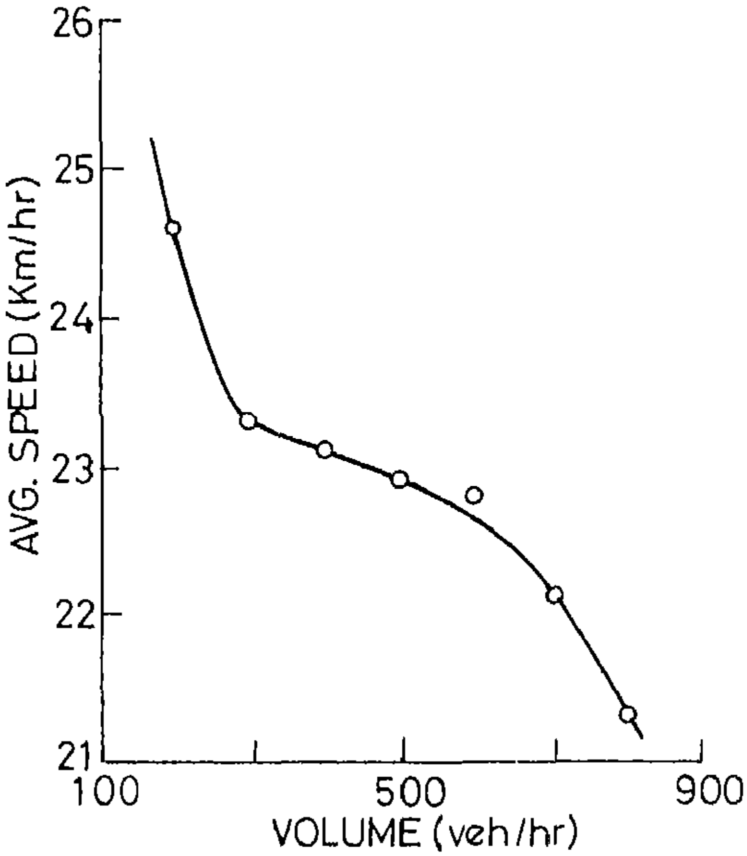


FIG. 4·13 AVG. SPEED FOR VARYING FLOW LEVEL

The best cycle length increases as flow level increases from 200 vph to 300 vph. For flow levels from 300 VPH to 700 vph, it is constant and again increases as the flow level increases so for flow level of 300-700 vph possible in normal and peak hours 55 secs is the best cycle length as seen from graph in Fig. 4.8.

Average delay is the least at 200 vph and it starts increasing as the volume or the flow level increases to 800 vph as shown by the curve in Fig. 4.9. The curve is steeper initially, then the slope decreases in the range of 300 vph-600 vph and again becomes steeper from the their on, as flow increases.

The percent stops also increase as the flow level increase as seen from graph in Fig. 4.10, until 700 vph, and after wards shows a decreasing trend. The rate of increase in stops is higher initially, then it decreases slightly at flow levels between 300 vph and 700 vph.

The PI as seen from the graph in Fig. 4.11 increases linearly almost as the flow level increases from 200 vph to 800 vph. The fuel consumption also increases linearly a seen from graph in Fig. 4.12, as the flow level increases.

The average speed of the network (Fig. 4.13) decreases as flow level increases, as it should be. The rate of decrease being higher initially, then decreases and then increases again at higher or peak volumes.

4.5.3 APPROACH SPEED:

The speed is varied from 25 kmph to 50 kmph where as the flow level of 500 vph, link length of 500 m and PDF of 0.35 are constant for all the runs. For all the other approach speeds, the MOE are estimated for the best cycle length and are as shown in Table 4.5.

As approach speed increases the optimum cycle length decreases initially in the range between 25 kmph to 30 kmph, from there on wards it increases to 70 secs steeply at 35 kmph. It remains constant for approach speeds of 30 to 45 kmph at 70 secs and then decreases again as speed increases further as seen from graph in Fig. 4.14.

The average delay decreases steeply as approach speed imcreases from 25 to 30 kmph, and then from 35 kmph to 50 kmph speed ranges it decreases as shown in graph in Fig. 4.15. The stops percent decrease gradually as speed increases (Fig. 4.17) from 30 kmph to 45 kmph, reaches a minimum value at 45 kmph , then increases as speed increases.

The PI as seen from graph (Fig.4.18) increases initially as speed increases indicating degeneration of performance of the signal timings plan, but from 35 kmph on wards as speed increases the PI decreases and reaches a minimum value at 50 kmph.

Fuel consumption decreases from 305.42 lit/hr at 25 kmph as the speed increases upto 45 kmph, but there on wards, shows a gradual increase as seen from graph (Fig. 4.18). The average speed of the network increaseslinearly as speed increases as seen from graph (Fig. 4.19).

TABLE 4.5 : PERFORMANCE TABLE - APPROACH SPEED IMPACT STUDY

Flow level : 500 VPH PDF = 0.35

Link Length : 500 m

Speed KMPH	Best Cycle Length Sec	Average Delay KMPH	Total Uniform Stops ./.	Total Fuel Consumption	PI	Average Speed KMPH
25	65	16.02	63	305.42	39.43	19.70
30	55	15.36	67	297.04	39.78	22.90
35	70	17.37	61	296.57	40.43	24.85
40	70	16.58	58	288.84	38.39	27.66
45	70	15.90	57	285.21	37.43	30.89
50	65	15.34	58	285.59	36.91	32.49

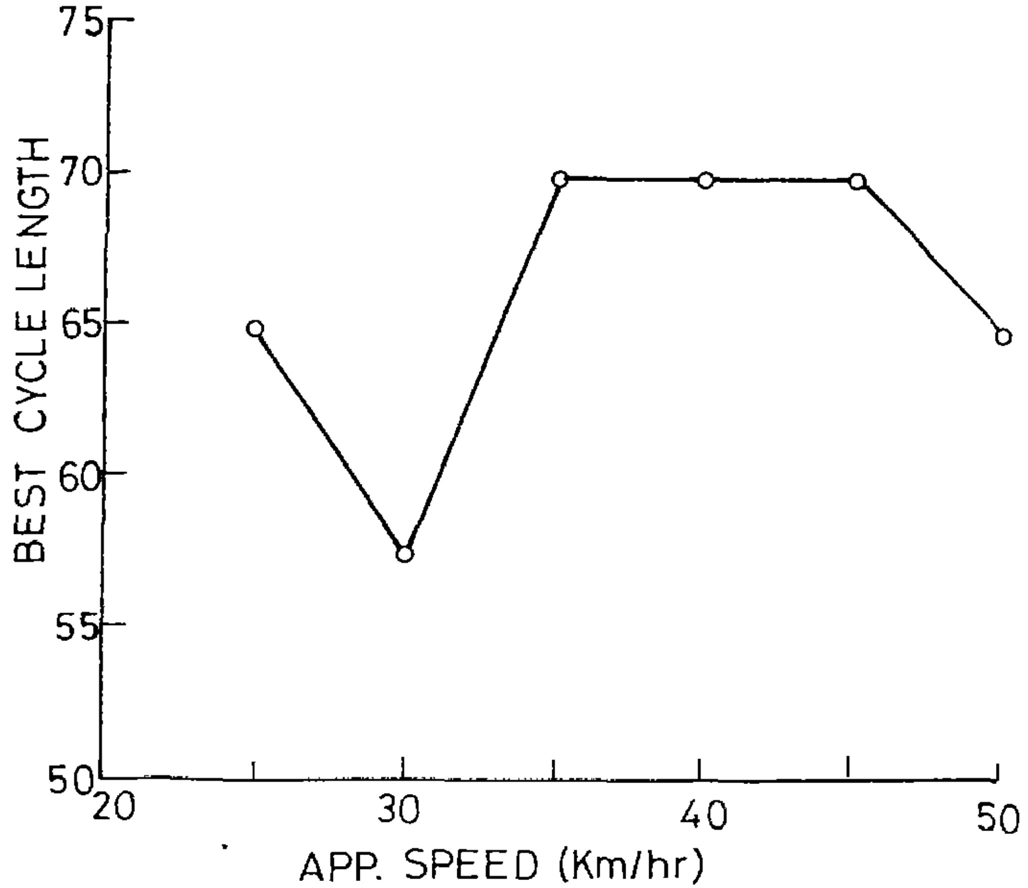


FIG. 4·14 BEST CYC LENGTH FOR VARYING APP. SPEED

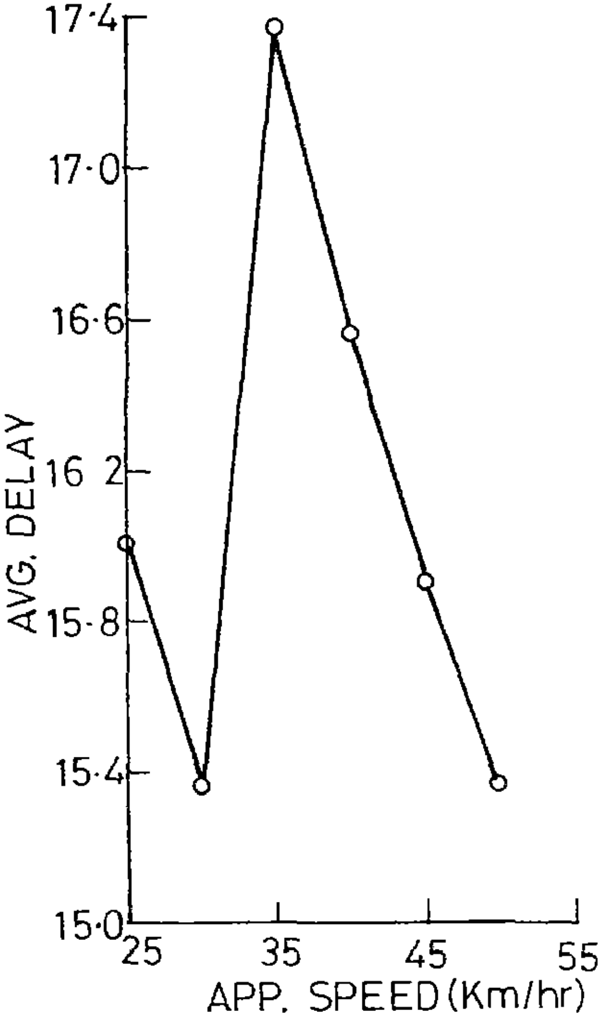


FIG.4·15 AVG. DELAY FOR VARYIN APP SPEED

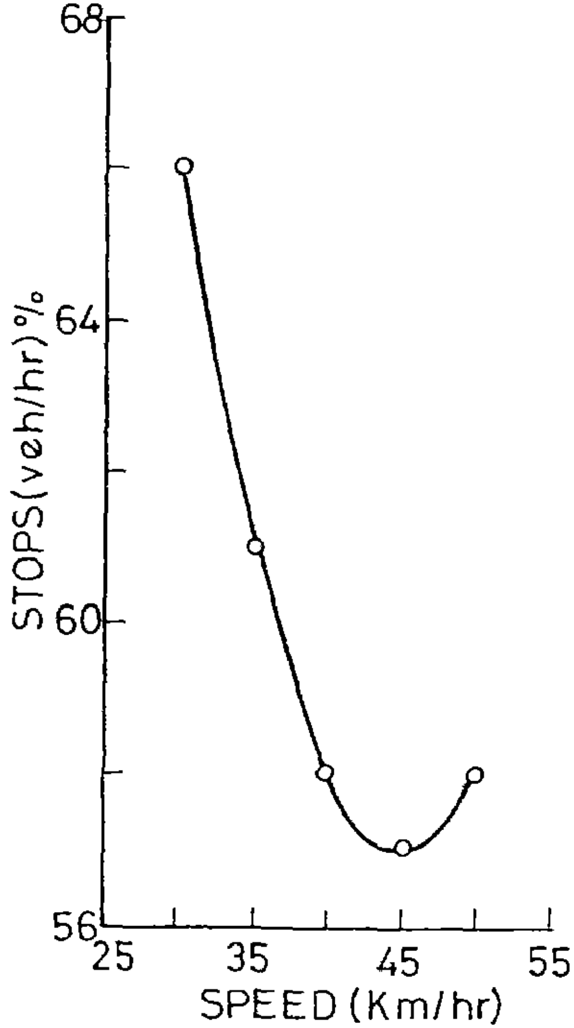


FIG.4·16 STOPS PERCENT FOR VARYING APP. SPEED

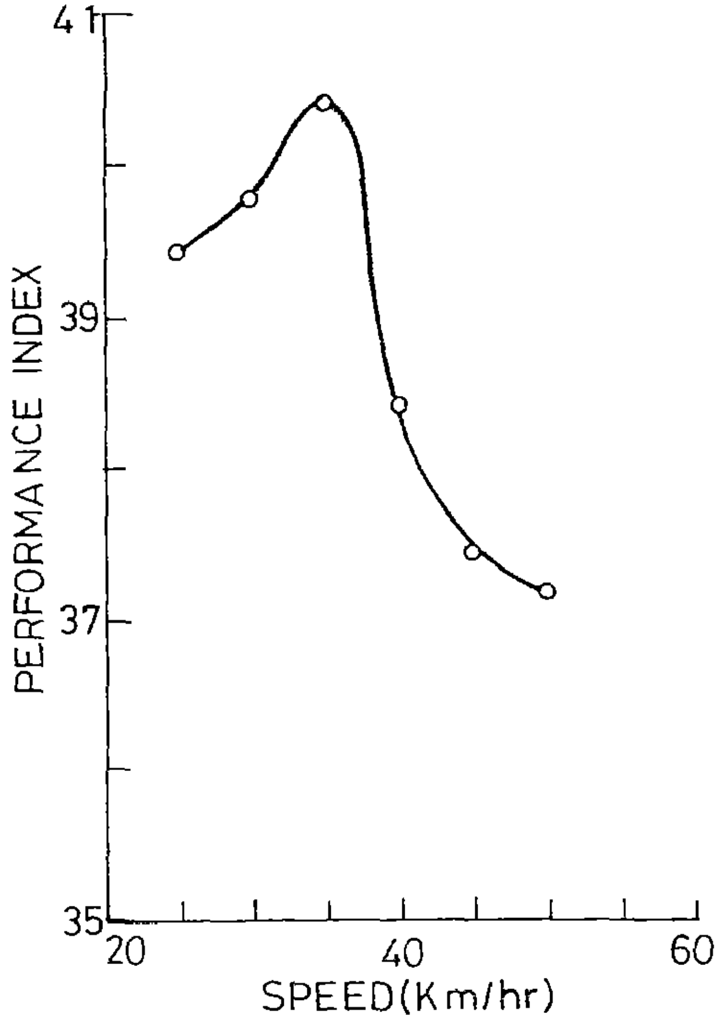


FIG.4·17 PI FOR VARYING APP SPEED

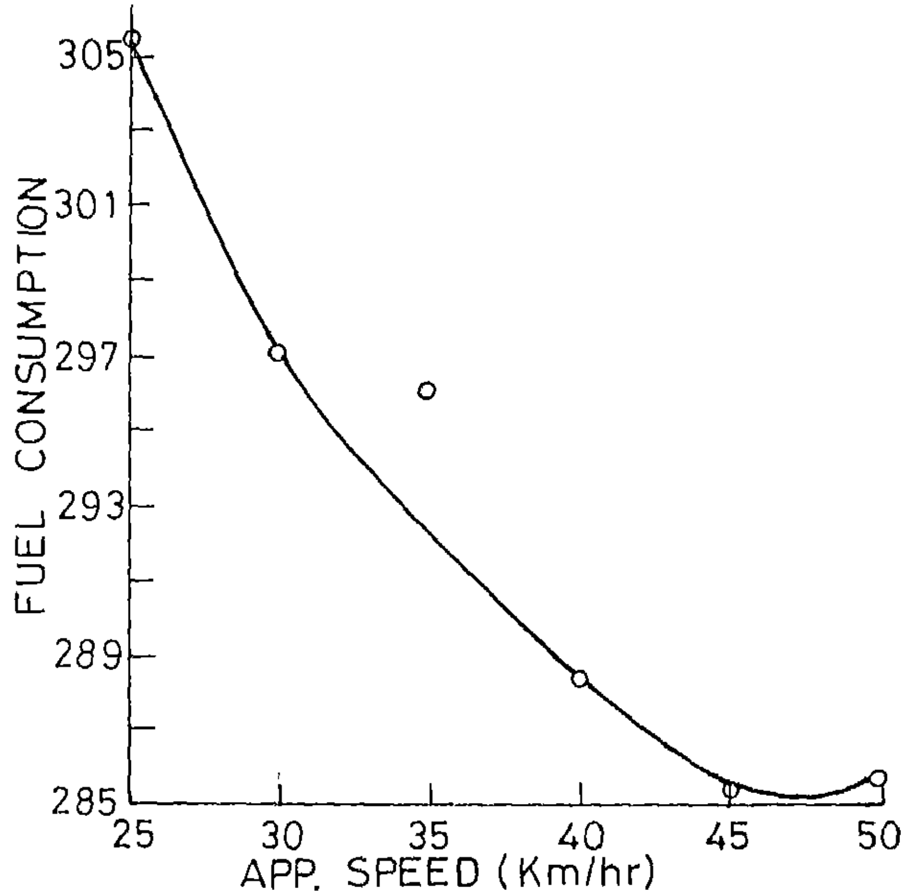


FIG.4·18 FC AT VARYING APP. SPEED

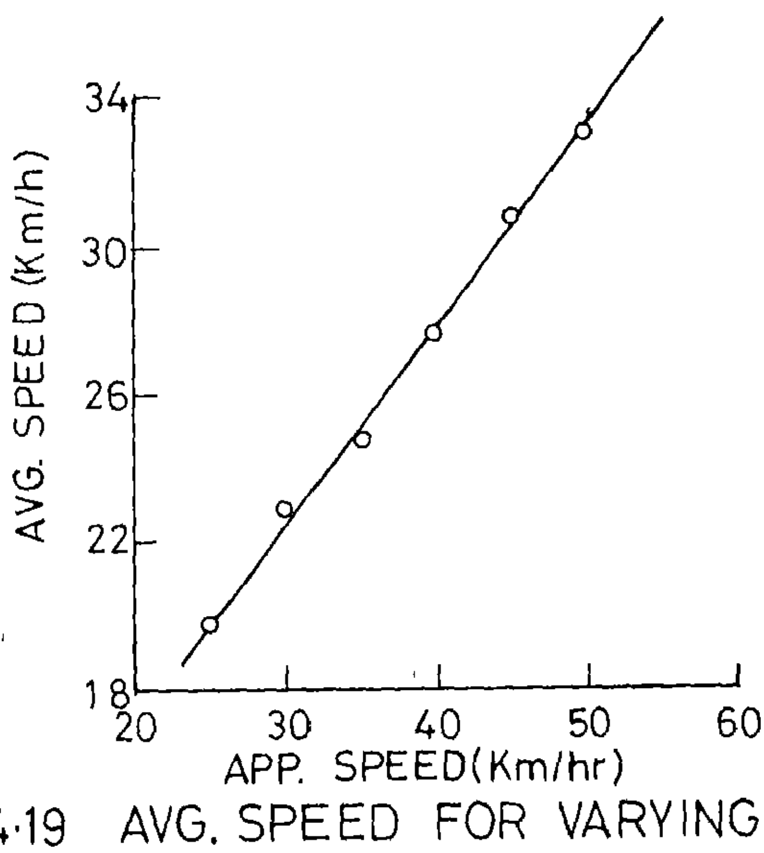


FIG.4·19 AVG. SPEED FOR VARYING APP. SPEED

We can conclude that at speeds of 30 kmph and above and upto a limit of 50 kmph the performance of the intersections improves, being better at higher speeds, i.e. in that range.

4.5.4 LINK LENGTH:

The link length is increased from 250 m to 1500 m at 250 m increase for every run. The flow level at 500 vph, speed at 30 kmph and PDF at 0.35 are constant and the MOE for the best cycle length in the range 35-70 selected for every alternate link length are as shown in Table 4.6.

As seen from graph as link length increases the best cycle length decreases in the range 250-500 m, and is the same for 750 m link length also, like at 500 m link length. It shows a increase as link length increases from 750 m to 1000 m from there on, it is constant as link length increases as seen from graph (Fig. 4.20).

As seen from graph (Fig. 4.21) the average delay increases gradually as link length increases. That is as the intersection spacing is increased the delay caused to vehicles increases. The stops also increase as link length increases from 250-750 m. In the range between 750 m to 1000 m it decreases and then again shows an increasing trend as link length increases as seen from graph (Fig. 4.22).

The performance index also increases as intersection spacing increases, indicating deteriroration in intersection performance, but in the range between 750 m to 1250 m increases the rate of increase of PI is less as seen from Fig. 4.23.

TABLE 4.6 : PERFORMANCE TABLE - LINK LENGTH IMPACT STUDY

Link Volume : 500 VPH   Speed : 30 Kmph

PDF : 0.35

Link Length (m)	Best Cycle Length (Sec)	Average Delay (Sec/Veh)	Total Uniform Stops (./.)	Total Fuel Consumption (Lit/hr)	PI	Average Speed (Kmph)
250	55	14.56	61	204.61	36.97	20.17
500	50	15.36	67	297.04	39.78	22.90
750	50	15.84	70	387.29	41.26	24.62
1000	65	16.93	65	476.66	40.95	25.21
1250	65	16.80	66	564.39	41.32	25.99
1500	65	17.09	68	653.51	42.36	26.48

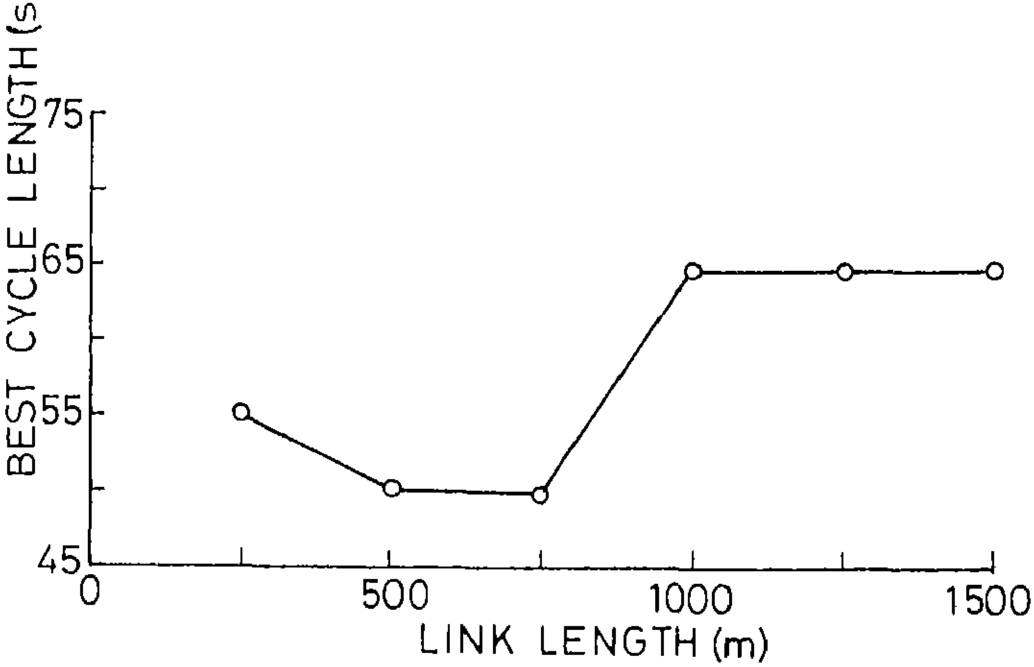


FIG. 4·20 BEST CYC LENGTH FOR VARYING LINK LENGTH

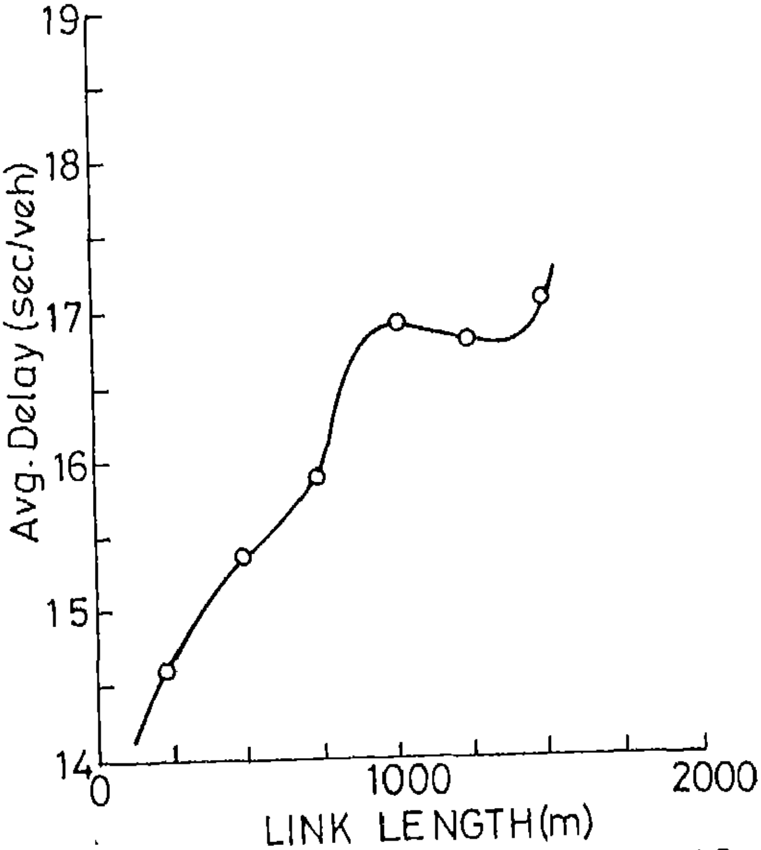


FIG. 4·21 AVG. DELAY FOR VARYING LINK LENGTH

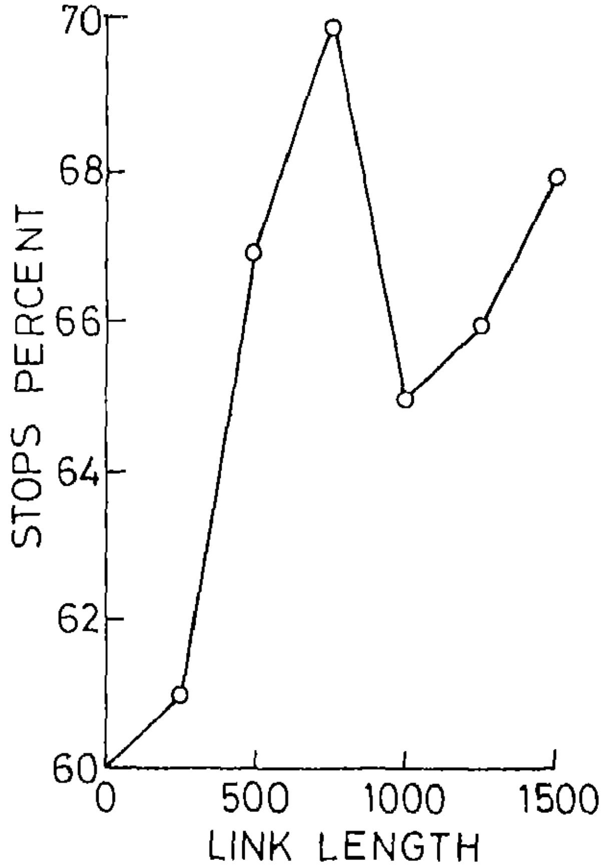


FIG.4·22 PERCENT STOPS FOR VARYING LINK LENGTH

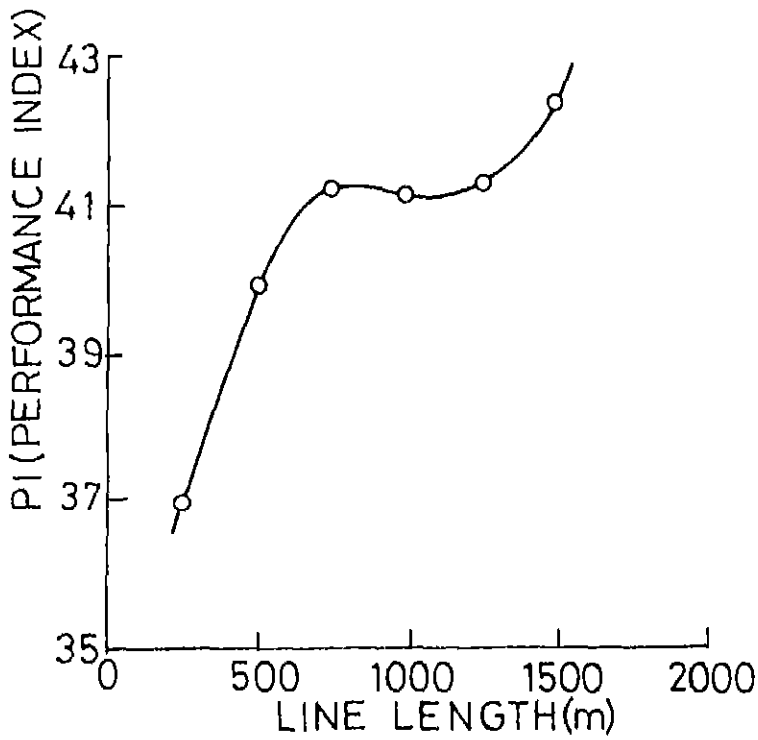


FIG.4·23 PI FOR VARYING LINK LENGTH

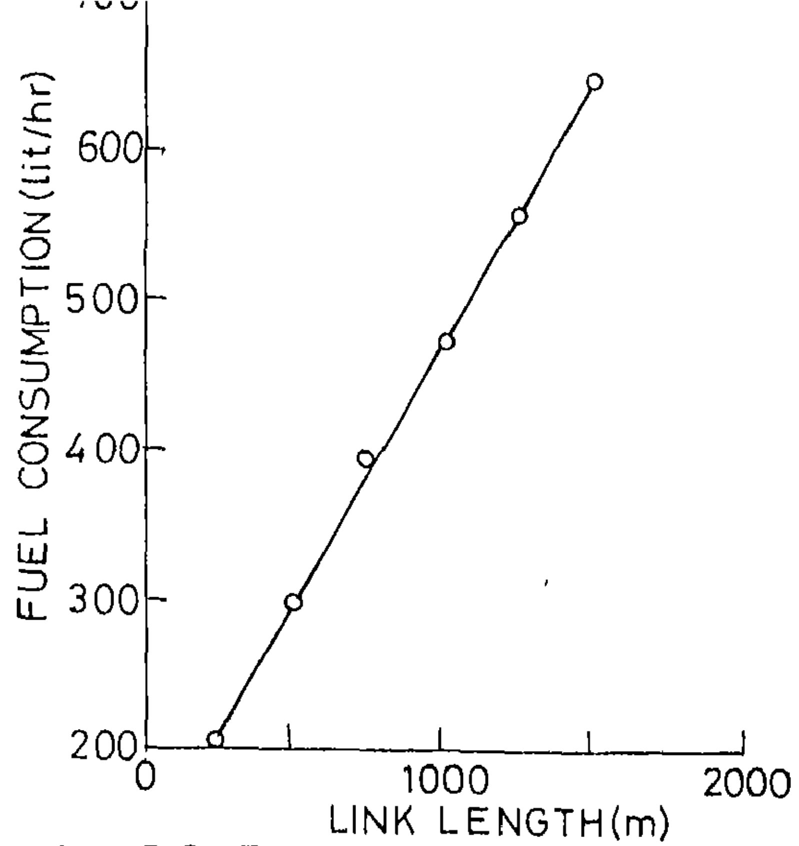


FIG.4·24 FC FOR VARYING LINK LENGTH

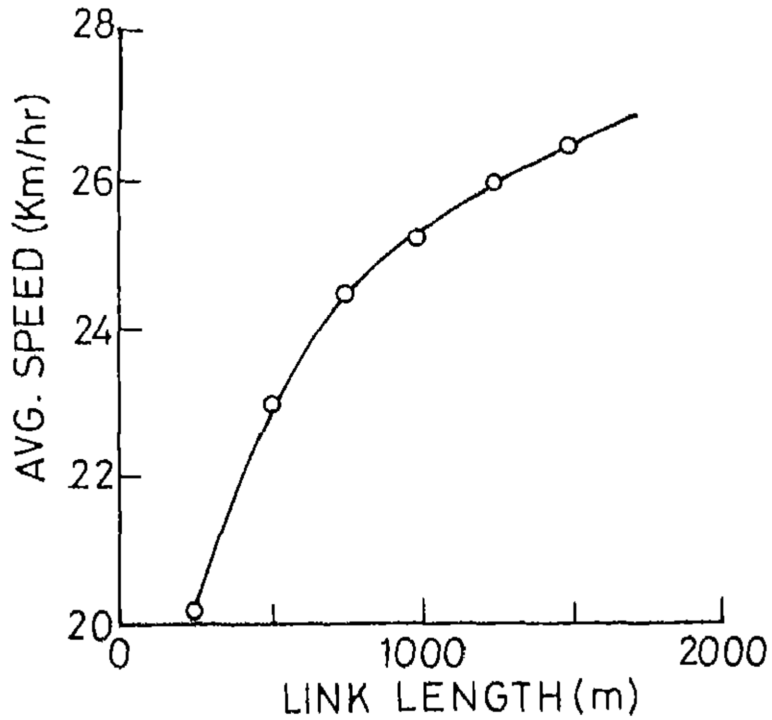


FIG.4·25 AVG. SPEED FOR VARYING LINK LENGTH

The fuel consumption varies linearly, it increases with increase in link length as in Fig. 4.24. This is because the overall distance travelled increases with the increase in intersection spacing.

The average speed increases gradually (Fig. 4.25) as the link length spacing increases as seen from graph, but at the same time all the other MOE show degeneration. It can be concluded that the performance of signalized intersection deteriorates with increase in intersection spacing.

4.5.5 Platoon dispersion factor: The platoon dispersion factor is varied for value of 0.25, 0.35 and 0.5 and the flow level of 500 vph, speed of 30 kmph link length of 500 m are kept constant for all the three runs. The values of MOE estimated by TRANSYT-7F for the best cycle length chosen in each case is as shown in Table 4.7.

When the PDF value is 0.25 the best cycle length is 50 secs but for other increased valued of PDF the best cycle length remains the same i.e. 55 secs cycle as seen from Fig. 4.26.

The average delay increases from 15.0 sec/veh to 15.76 sec/veh as PDF increases as seen from Fig. 4.27. The stops percent of vehicles also increases linearly with the increase of PDF as seen from graph (Fig. 4.28).

The PI also shows a gradual increase as PDF increase and is least at 0.25 PDF as seen in Fig. 4.29. The fuel consumption also increases as PDF increases as seen from graph (Fig. 4.30).

TABLE 4.7 : PERFORMANCE TABLE - PDF STUDY

Link Volume : 500 VPH Link Length : 500 m

Speed : 30 Kmph

PDF	Best Cycle Length (Sec)	Average Delay (Sec/Veh)	Total Uniform Stops (./.)	Total Fuel Consumption	PI	Average Speed (Kmph)
0.25	50	14.99	65	295.09	68.9	38.74
0.35	55	15.36	67	297.04	67.8	39.78
0.50	55	15.76	69	298.88	67.2	40.68

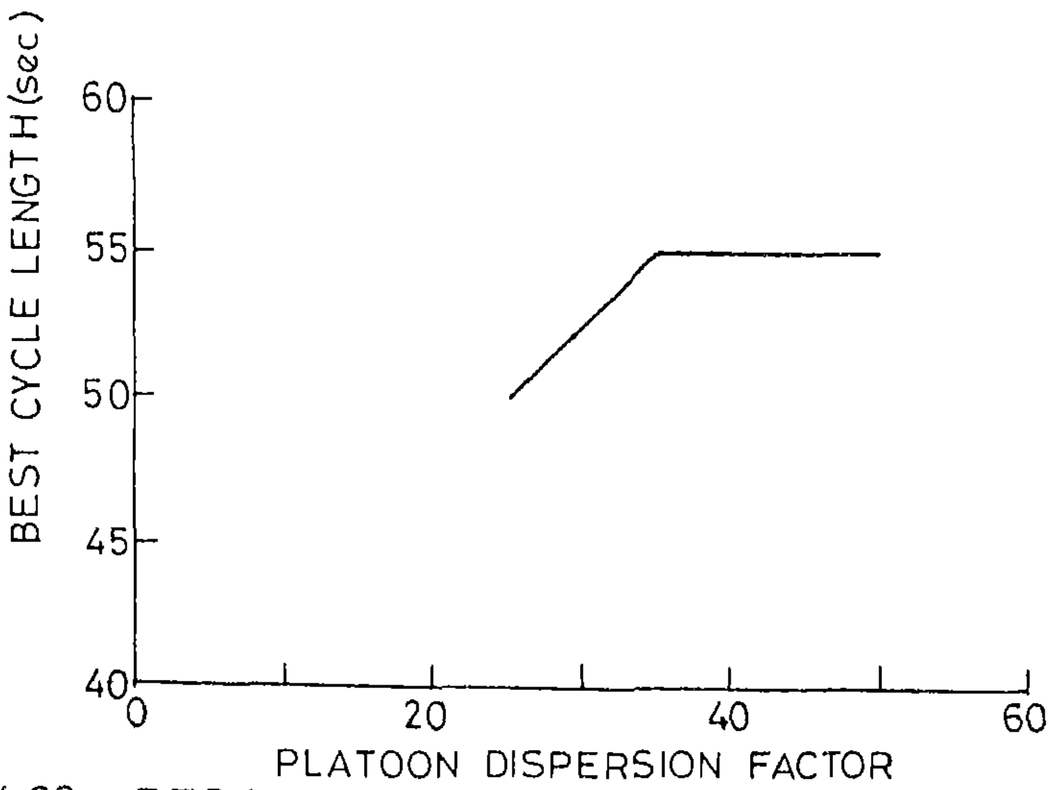


FIG.4·26 BEST CYCLE LENGTH FOR VARYING PDF

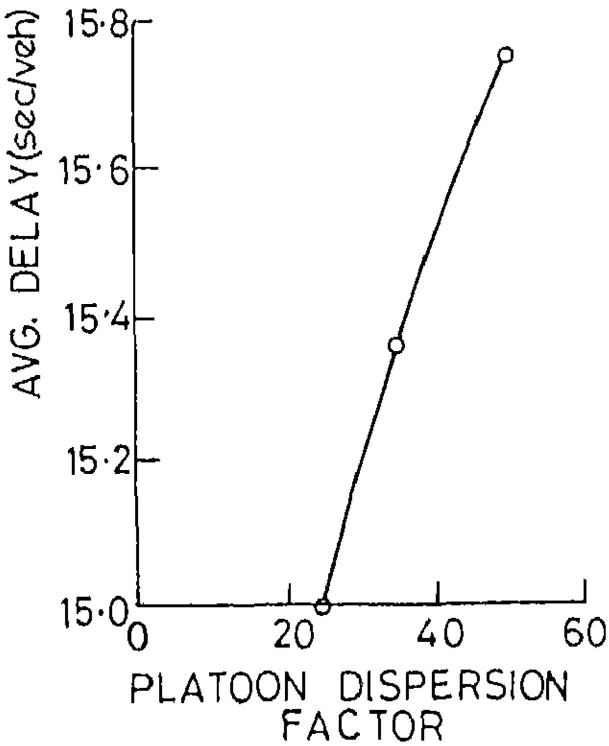


FIG.4·27 AVG. DELAY FOR VARYING PDF

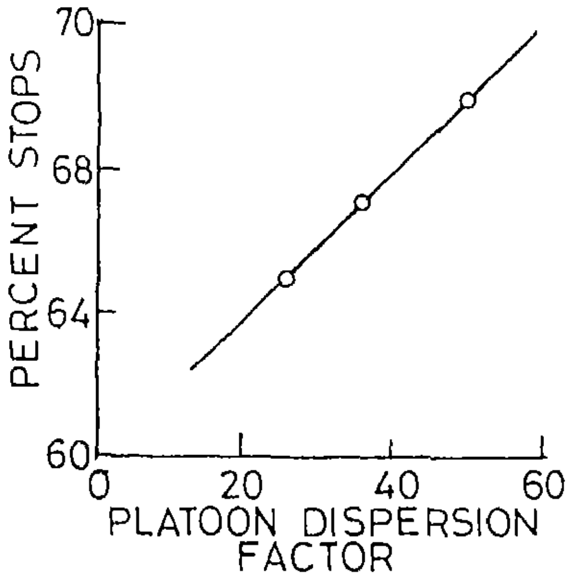


FIG.4·28 PERCENT STOPS AT DIFFERENT PDF

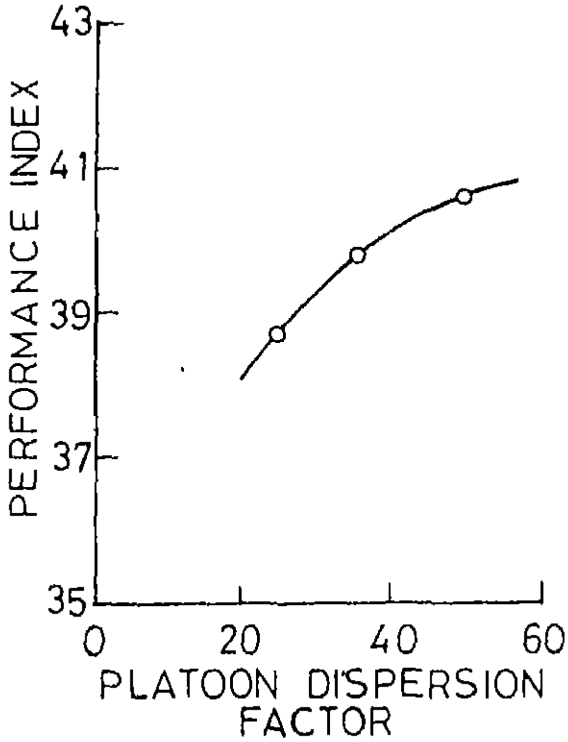


FIG.4·29 PI FOR VARYING PDF

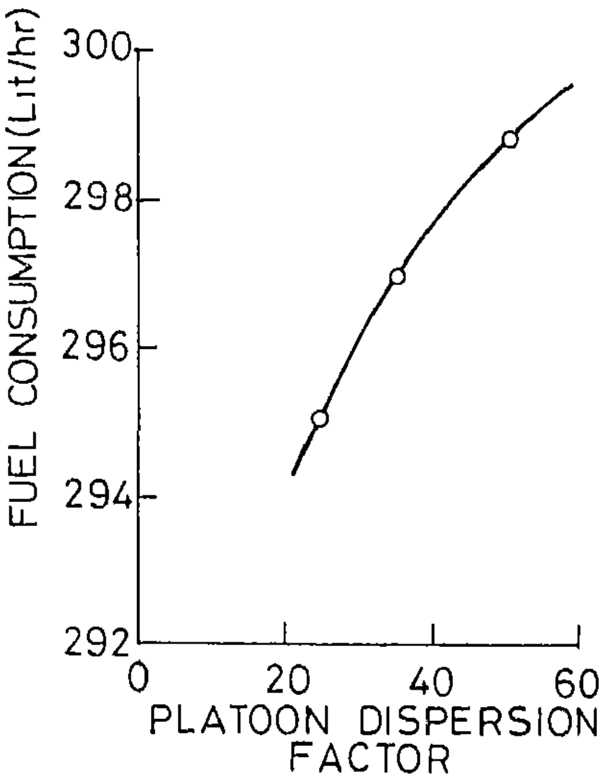


FIG. 4·30 FC FOR VARYING PDF

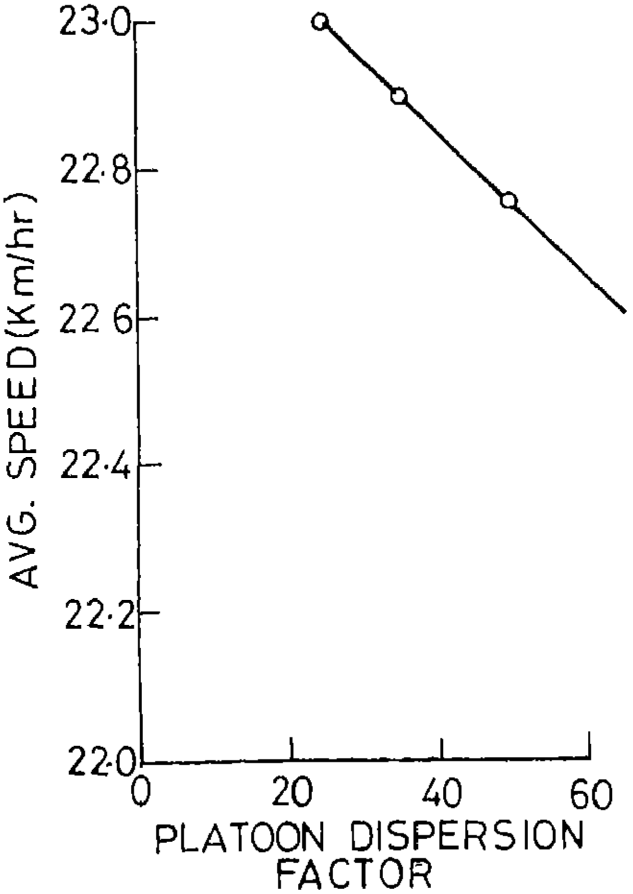


FIG. 4·31 AVG. SPEED FOR VARYING PDF

The average speed of the network decreases as PDF increases as seen from graph (Fig. 4.31).

As the PDF increases the road way characteristics worsen as also the traffic flow conditions. So we can conclude that as PDF increases (or) when the flow conditions degenerate the performance of the signalized intersection also degenerates.

4.6 CASE STUDY - II :

4.6.1 DESCRIPTION:

Here it is decided to study the behavioural pattern of the TRANSYT-7F model in predicting the performance of the signalized intersections, and its sensitivity to varying flow parameters as in the previous case study, but for a problem of bigger magnitude. Hence an urban corridor with six signalised intersections is considered for this case study.

The corridor considered is a four lane road, with two lanes serving for traffic in each direction. A 4 phase fixed signal timing control is selected. The flow level on the minor street is one half of that on major street in this case too. The same parameters as in the case of previous case study are identified for sensitivity study, and also judging the performance of TRANSYT-7F model. They are

- Cycle length of signal timing
- Volume of traffic
- Approach speed of traffic flow
- Link length of intersections
- PDF.

TABLE 4.8 : DETAILS OF INPUT- SENSITIVITY ANALYSIS - CASE STUDY - I

Sensitivity Analysis Parameters Under Study	Range of Variation	Step Size for Each Run	Constant Values of Parameters of Traffic Flow for Present Study			
			Speed Kmph	Link Length m	PDF	Volume of Traffic VPH
Cycle Length (Sec)	40-120	5	30	500	0.35	600
Volume of Traffic Flow VPH			Speed KMPH	Link Length (m)	PDF	Cycle Length (sec)
	300-1000	100	30	500	0.35	Best
Speed of Flow KMPH			Volume of Traffic VPH	Link Length (m)	PDF	Cycle Length (sec)
	25-60	5	600	500	0.35	Best
Link Length of Corridor (m)			Speed KMPH	Link Volume VPH	PDF	Cycle Length (Sec)
	500-2000	250	30	600	0.35	Best
PDF Value Input			Speed KMPH	Link Length (m)	Volume of Traffic VPH	Cycle length (Sec)
	0.25, 0.35 and 0.5 only	-	30	500	600	Best

The sensitivity analysis is performed similarly as in the previous case , and the range of parameter value for which sensitivity is tested, under particular flow conditions are listed in Table 4.8.

4.6.2 INPUTS:

Network data: The corridor is precoded into a system of 6 nodes and 8 links following the same nomenclature and procedur as in the previous case study. The layout of the corridor is as shown in Fig. 4.34.

Signal timing parameters: The cycle length for which cycle evaluation is done in each run, and the range over which sensitivity is tested is 40-120 seconds. A 4 phase sequence of signal indications is selected for this case study at each intersection. In phase-1 the right of way is for direction of traffic along lanes 101 and 102. In the subsequent three phases, the direction of movement is for traffic along lanes 103 and 104, 105 and 106 and 107 and 108 respectively.

The values of start up lost time and extension of effective green input are 3 seconds and 2 seconds, simulating normal behavioural pattern of drivers. All the other signal timing parameter inputs are more or less similar as in the previous case study and as tabulated in Table 4.9.

Geometric and traffic data: In the analysis of the sensitivity of the model to link length variation, the range of link length input is 500 m - 2000 m. The flow level of traffic input, varies in the range 300 vph - 1000 vph in this case study.

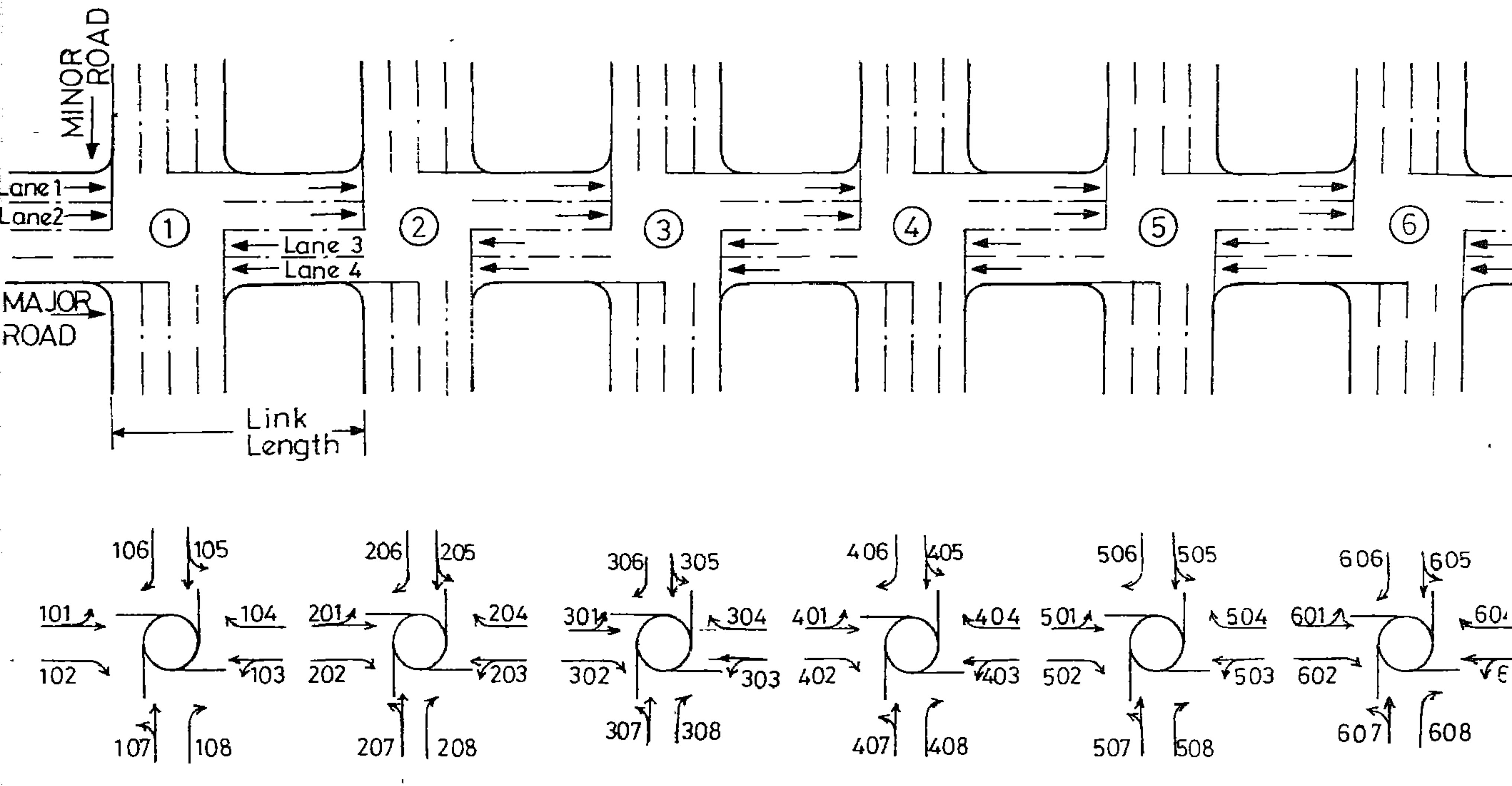


FIG.4·32 LAYOUT OF SIX INTERSECTION CORRIDOR

TABLE 4.9 : INPUT DATA REPORT

Signal Timing Parameters	Range	Geometric and Traffic Data	Range
Cycle Length	40-120 secs	Link Volume	300-1000 VPH
Number of phases	4	Link Length	500-2000 m
Minimum Phase Length	10 sec	Stop Penalty	25
Startup Lost Time	3 sec	Cruise speed	25-60
Extension of Effective Green	2 sec	PDF	0.25-0.35 and 0.5

All the other data input are similar to the earlier case study and as shown in Table 4.9.

Control data: The options chosen and the types of runs made, are similar as in the previous case study.

4.6.3 OUTPUT:

The various output of TRANSYT-7F considered in this case study are

- Input data report
- Cycle evaluation summary
- Performance table.

The input data report and the cycle evaluation summary output are similar as in the previous case study, but for six-intersections in this case.

The performance table with all the MOE is printed, with MOE indicated for each link, subtotaled by intersection and then aggregated for the entire network. The various MOE considered are also similar as in the previous case study. They are average delay, total uniform stops, fuel consumption, PI, average speed of network etc.

4.7 DISCUSSION OF RESULTS FOR CASE STUDY II:

4.7.1 CYCLE LENGTH:

In the cycle length sensitivity analysis test runs, the cycle length is varied in the range 40-70 seconds with a step increase of 5 seconds for every run where as other flow conditions such as flow level at 600 vph, speed at 30 kmph,

link length at 500 m and PDF at 0.35 are constant through out this runs. The MOE are tabulated for the best cycle length as shown in Table 4.10.

Best cycle length: The best cycle length is the one for which the PI is the least. All the other MOE are also almost best values for this cycle length. The best cycle length for volume of traffic between 300 vph - 600 vph is 55 seconds.

Average delay as seen from graph in Fig. 4.33 decreases as the cycle length increases from 40 to 60 seconds, to a minimum value of 22.52 sec/veh, and then again increases to 23.77 sec/veh at 70 sec cycle length. The precent stops as seen from graph in Fig. 4.34 decreases from 90 percent at 45 secs cycle length to 81 percent at 50 and 55 secs cycle length. From there onwards it again increases steadily.

The PI as seen from Fig. 4.35 also decreases, reaches a minimum value at 55 secs length, and then again increases from there onwards indicating degeneration of traffic performance. The PI is the minimum at 55 secs cycle length and hence the best cycle length.

The fuel consumption as seen from graph in Fig. 4.36 also shows the same trend as other MOE ie, it decreases reaches a minimum value at best cycle length and then from there onwards increases.

TABLE 4.10 : PERFORMANCE TABLE - CYCLE LENGTH IMPACT STUDY

Traffic Volume : 600 Veh/hr, Approach speed : 30 Kmph

Link Length : 500 m PDF : 0.35

Cycle Length (Sec)	Average Delay (Sec/Veh)	Percent Stops (./.)	Fuel Consumption (Gal/Hr)	Performance Index (PI)
45	29.62	90	971.0	156.1
50	23.73	81	914.2	131.7
55	22.55	81	904.6	128.4
60	22.52	83	906.3	130.0
65	22.97	82	909.1	130.5
70	23.77	85	917.9	134.8

4.7.2 VOLUME:

In this analysis of the sensitivity of the model to fluctuations in link volume, the volume is varied in the range 200 vph - 1000 vph with step increase of 100 vph for every run. The other parameters, such as speed at 30 kmph, link length at 500 m and PDF at 0.35 are constant for these runs. The best cycle length is evaluated in each case, and the MOE obtained for that cycle length, are as shown in Table 4.11.

The optimum cycle length as seen from graph in Fig. 4.37 is the same for all the flow levels from 300 vph to 600 vph. But from there onwards it shows a very steep increase as volume on link incfeases and reaches a maximum of 115 secs at 1000 vph volume.

The average delay as seen from graph in Fig. 4.38 increases gradually with the increase in volume, which can very well be understood as due to increase of interactions among vehicles. The percentage stops (Fig. 4.39) also increases as the volume increases upto a flow level of 800 vph but from there onwards stops decrease as the volume on the link increases.

The performance index of the corridor as seen from Fig. 4.40 gradually increases with the increase in volume showing degeneration of performance of intersections as the traffic volume increases.

The fuel consumption as seen from Fig. 4.41 also increases as the volume increases due to increase in delay and stops. The average speed (Fig. 4.42) with which the vehicles actually

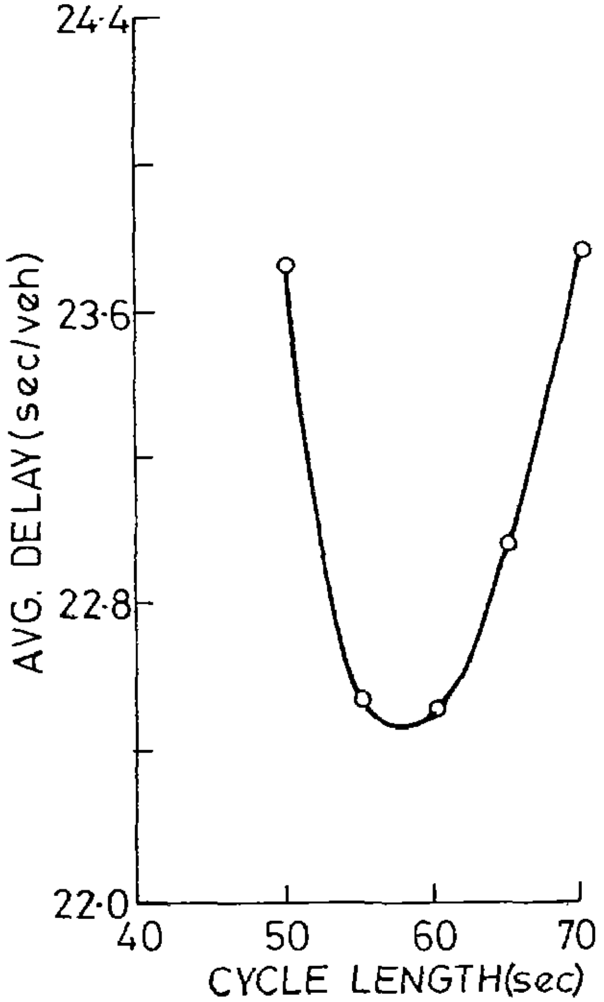


FIG. 4·33 AVG. DELAY FOR VARYING CYC LENGTH

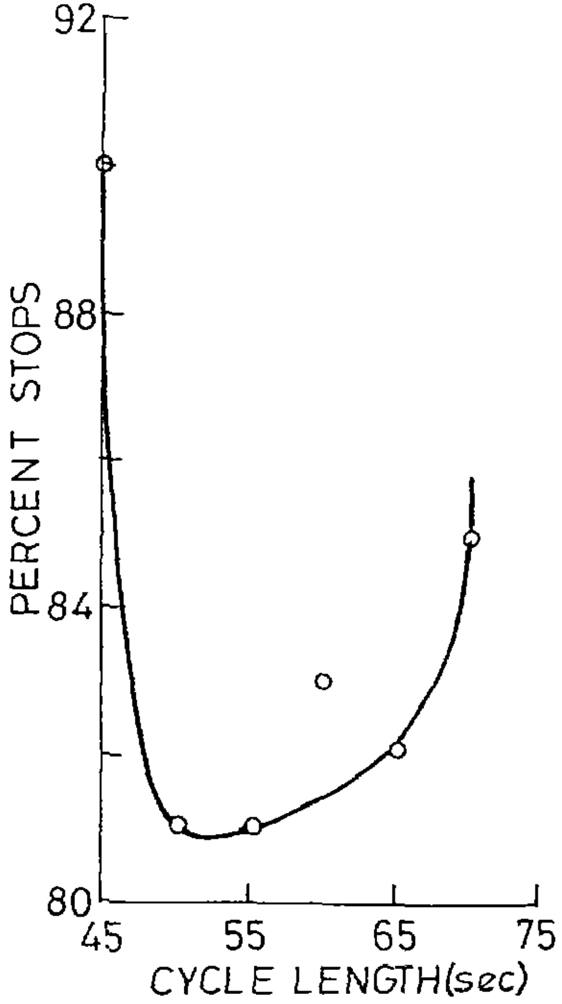


FIG. 4·34 PERCENT STOPS FOR VARYING LENGTH

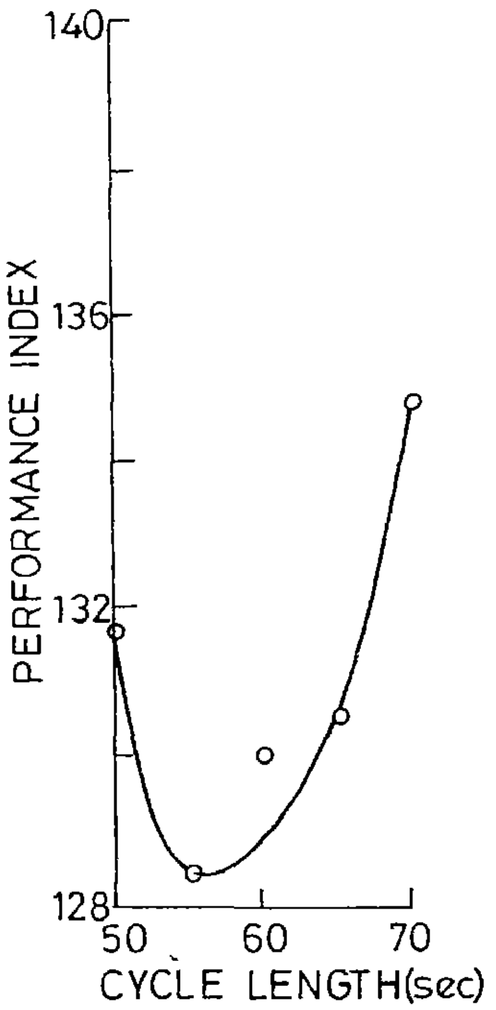


FIG.4·35 PI FOR VARYING CYC LENGTH

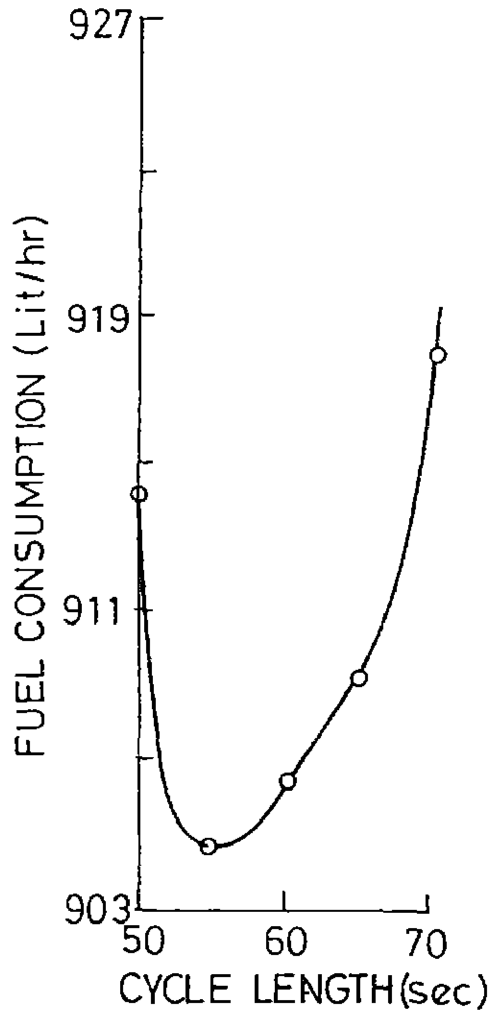


FIG.4·36 FC FOR VARYING CYC LENGTH

TABLE 4.11 : PERFORMANCE TABLE - VOLUME IMPACT STUDY

Speed : 30 Kmph Link Length : 500 m

PDF : 0.35

Volume of Link Flow VPH	Best Cycle Length	Average Delay Sec/Veh	Total Uniform Stops ./.	Total Fuel Consumption Lit/hr	PI	Average Speed KMPH
300	55	18.55	73	427.55	54.73	22.92
400	55	19.42	76	582.86	76.88	22.67
500	55	20.64	79	738.90	100.74	22.32
600	55	22.55	81	904.51	128.34	21.80
700	65	25.12	86	1085.07	162.85	21.15
800	70	29.30	89	1290.30	205.96	20.16
900	110	39.05	81	1562.28	266.44	18.17
1000	115	45.31	86	1830.22	233.89	17.09

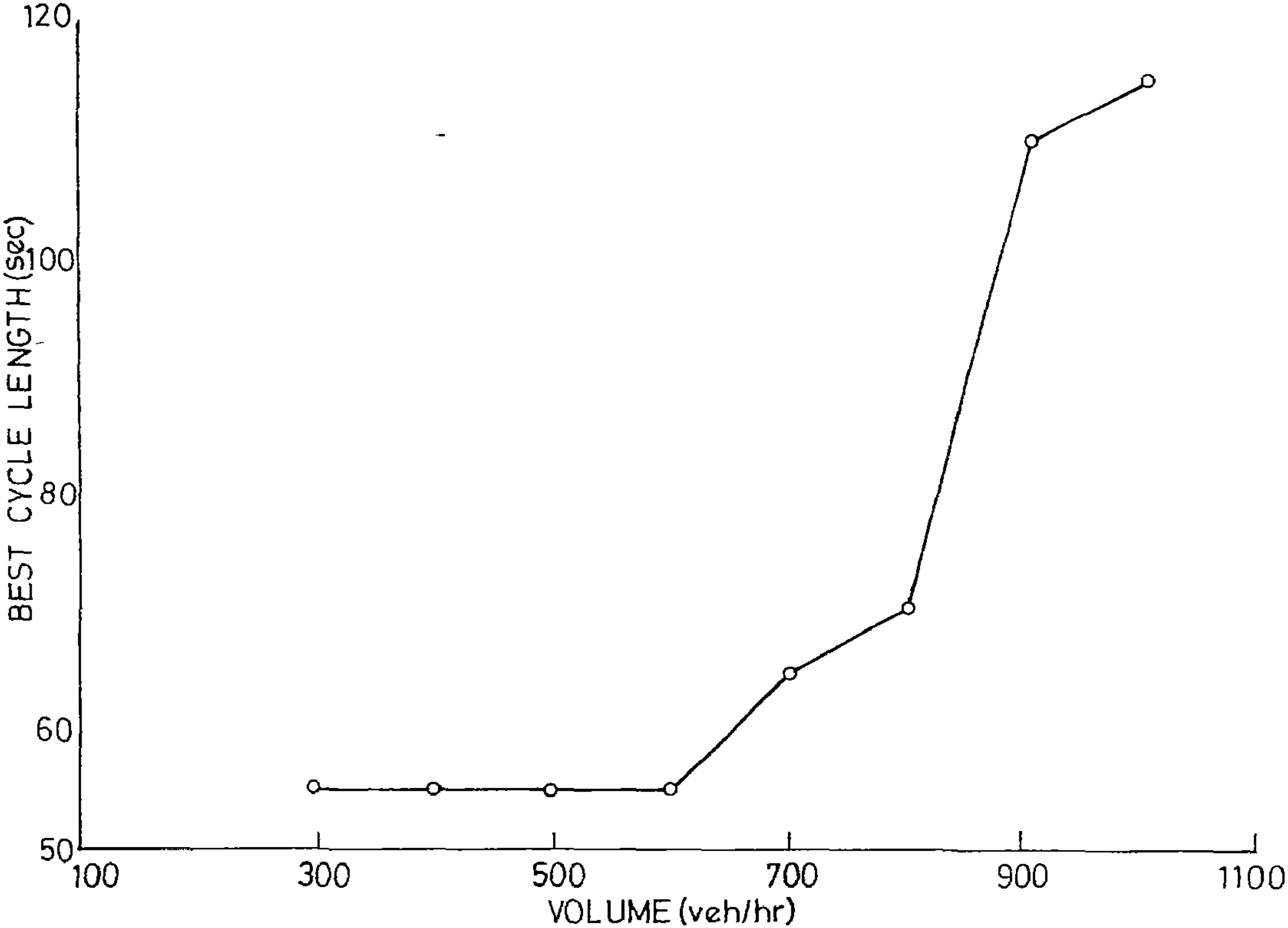


FIG. 4.37 BEST CYCLE LENGTH FOR VARYING FLOW LEVEL

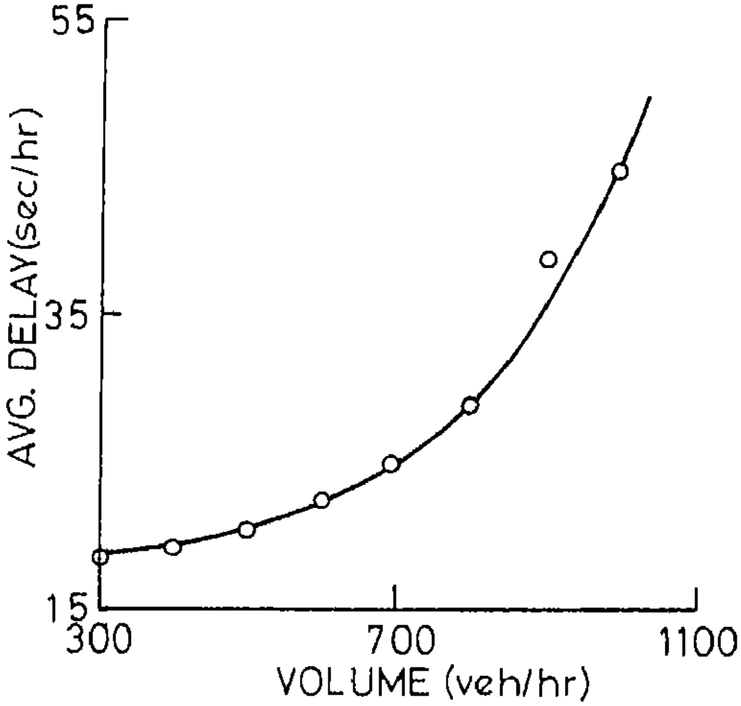


FIG. 4·38 AVG. DELAY FOR VARYING FLOW LEVEL

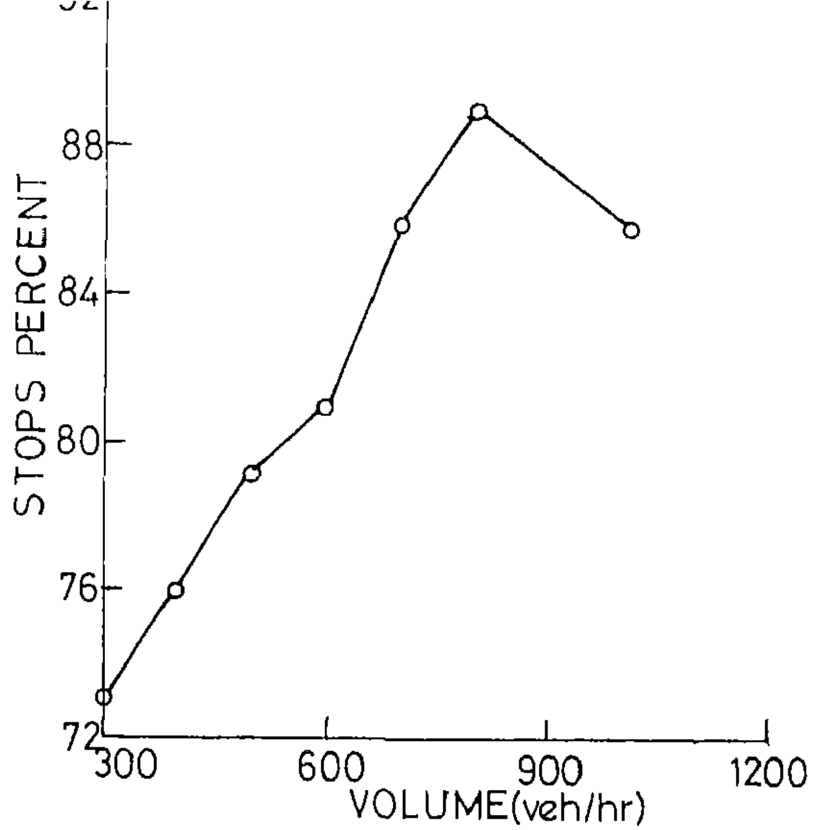


FIG. 4·39 STOPS PERCENT FOR VARYING FLOW LEVEL

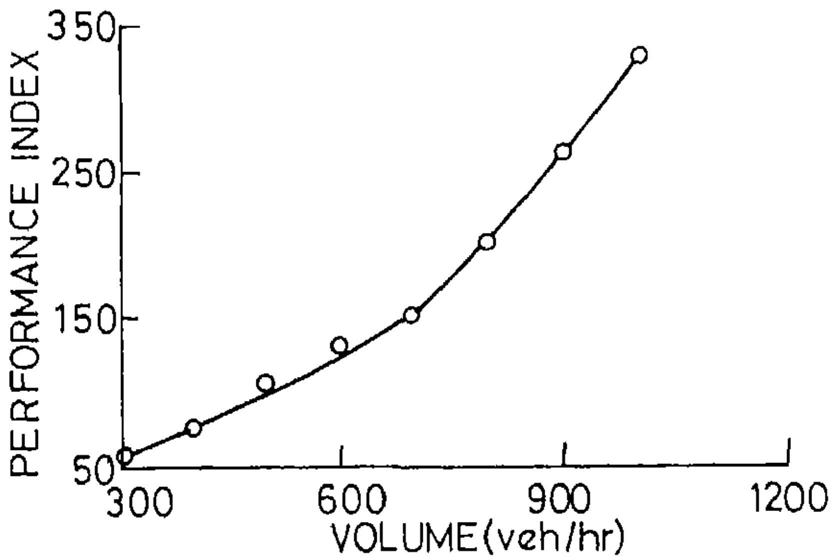


FIG.4·40 PI FOR VARYING FLOW LEVEL

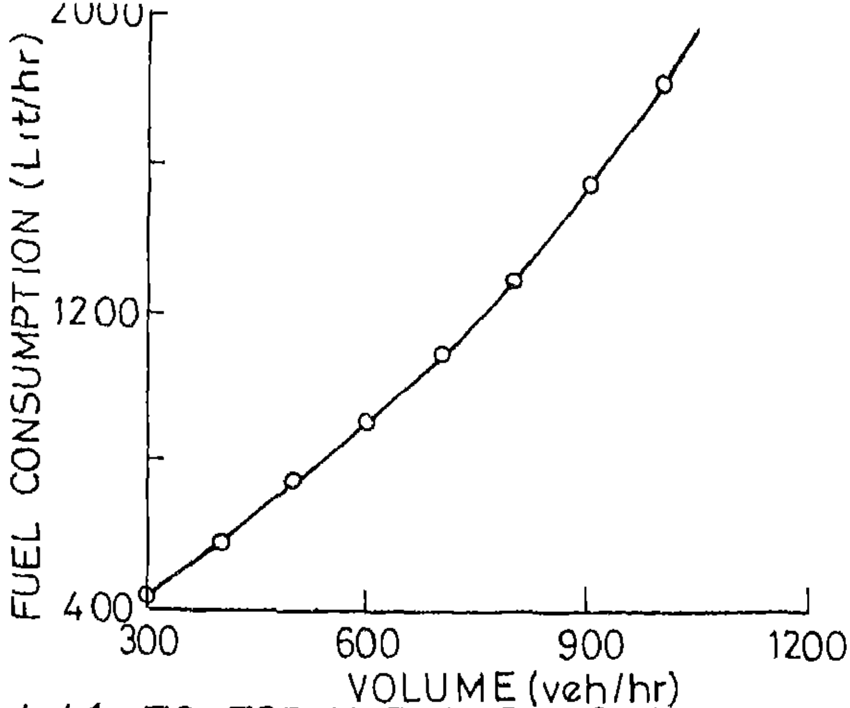


FIG.4·41 FC FOR VARYING VOLUME

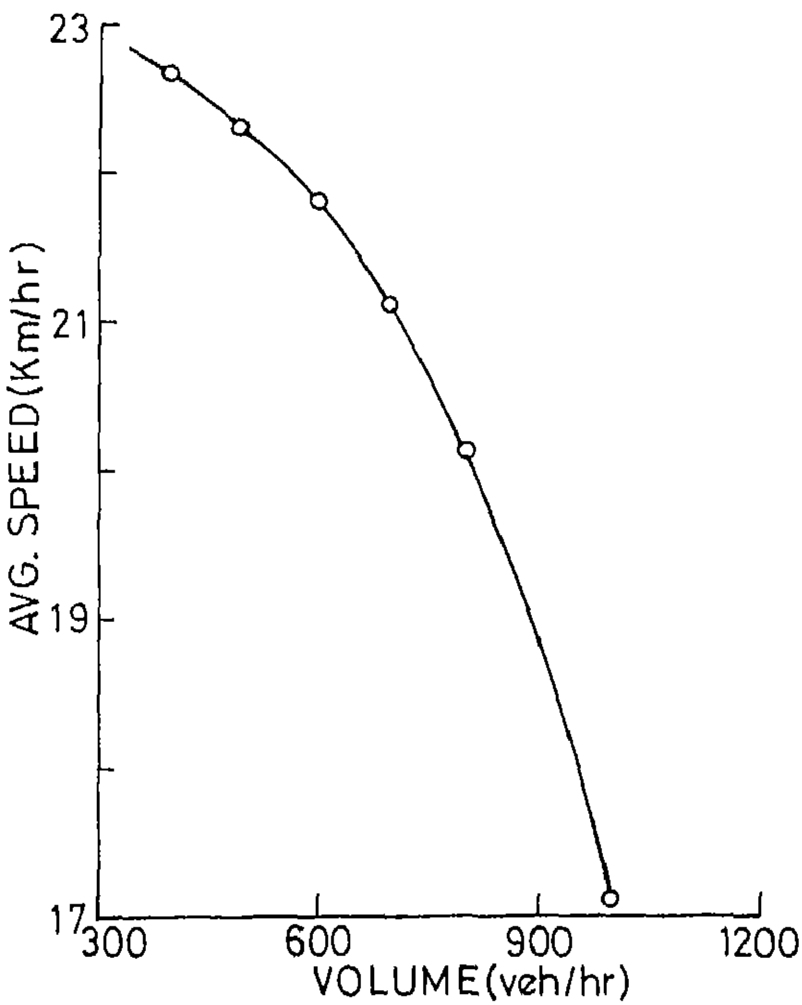


FIG.4·42 AVG. SPEED FOR VARYING FLOW LEVEL

travel in the network decreases as the volume on the link increases, as is expected due to more interaction between vehicle The average speed is the minimum at 1000 vph at 17.09 kmph and maximum at 300 vph at 22.92 kmph.

4.7.3 APPROACH SPEED:

To test the sensitivity of this parameter, on the model and the performance of intersections, is varied in the range 25-60 kmph with a step increase of 5 kmph for every run. In all these runs the constant values of other parameters are 600 vp flow level, 500 m link length and 0.35 PDF. In each case the MOE are tabulated for the best cycle length evaluated and shown in Table 4.12.

Regarding the selection of the best cycle length, initially as the approach speed increases the cycle length decreases from 65 seconds at 25 kmph speed to 50 seconds at 35 kmph speed. From there onwards it fluctuates with out a particular trend. The approach speed at the minimum cycle length evaluated (50 seconds) is 35 kmph as seen from graph in Fig.4.43

The average delay also shows a increasing and decreasing trend, with out particular pattern of variation. The minimum delay is at 35kmph speed being 21.84 sec/veh and the maximum delay at 40 kmph being 26.24 sec/veh as seen from Fig. 4.44.

The stops perpent increases as the approach speed increases upto 35 kmph, but from there, it decreases to a minimum at 40 kmph approach speed, and then starts increasing again upto 50 kmph approach speed. From here onwards approach speed increas

TABLE 4.12 : PERFORMANCE TABLE - SPEED IMPACT STUDY

Flow Level : 600 VPH   Link Length = 0.5 Km

PDF : 0.35

Flow Speed KMPH	Best Cycle Length Sec	Average Delay Sec/Veh	Total Uniform Stops ./.	Total Fuel Comsum-ption	PI	Average Speed KMPH
25	65	23.63	78	932.56	129.25	18.82
30	55	22.55	81	904.57	128.34	21.80
35	50	21.89	83	893.22	128.06	23.34
40	80	26.24	70	905.81	131.38	23.11
45	70	24.19	72	886.71	126.19	24.69
50	75	26.58	77	913.62	137.52	27.03
55	70	25.33	77	908.19	133.54	28.34
60	65	22.47	77	895.91	125.30	30.44

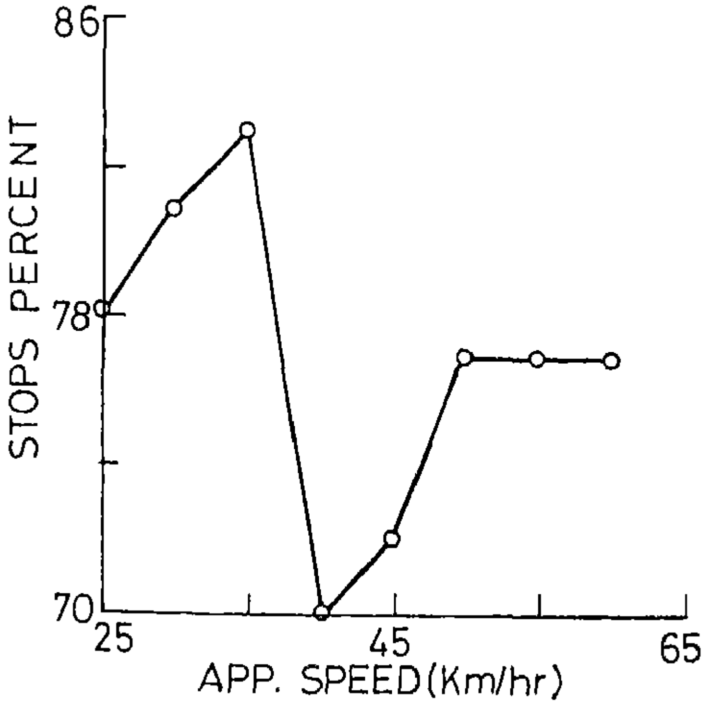


FIG. 4·45 STOPS PERCENT FOR VARYING APP. SPEED

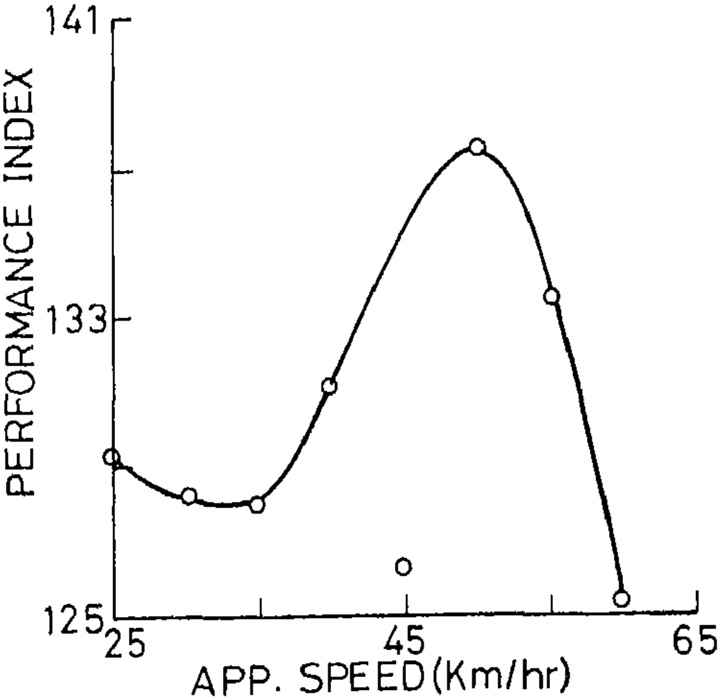


FIG. 4·46 PI FOR VARYING APP. SPEED

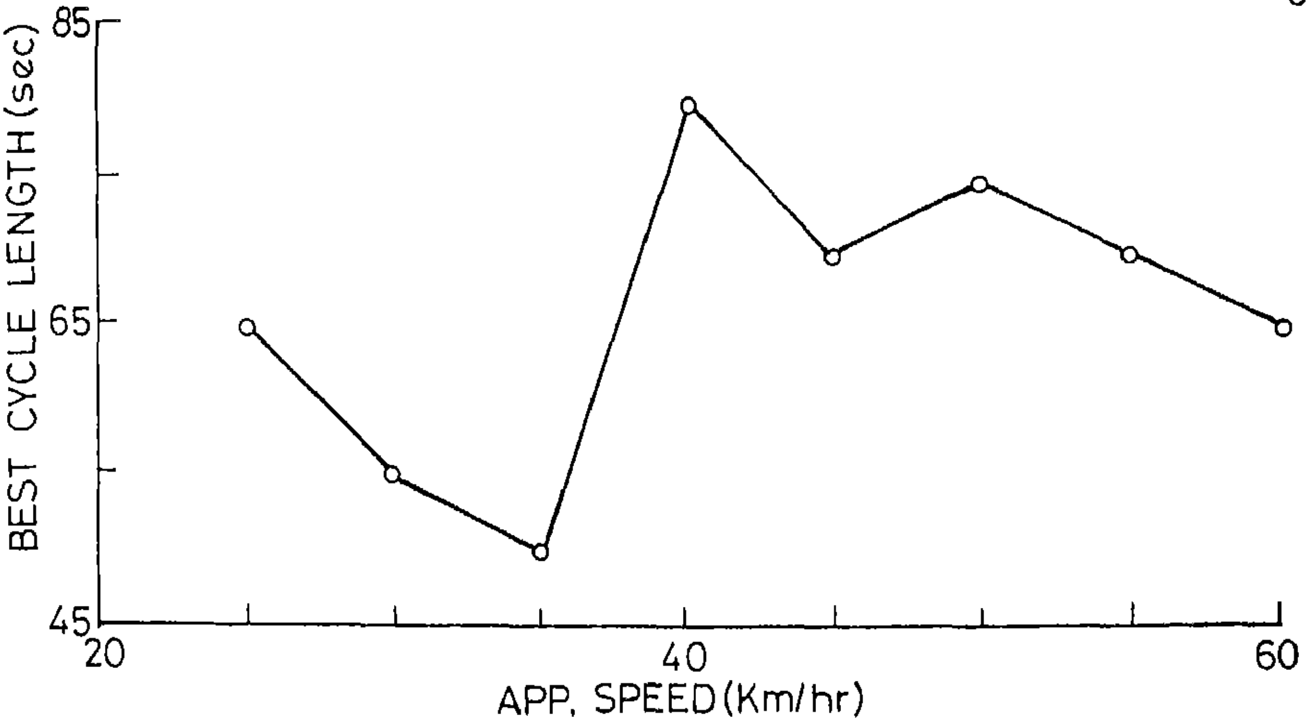


FIG.4·43 BEST CYC LENGTH FOR VARYING APP. SPEED

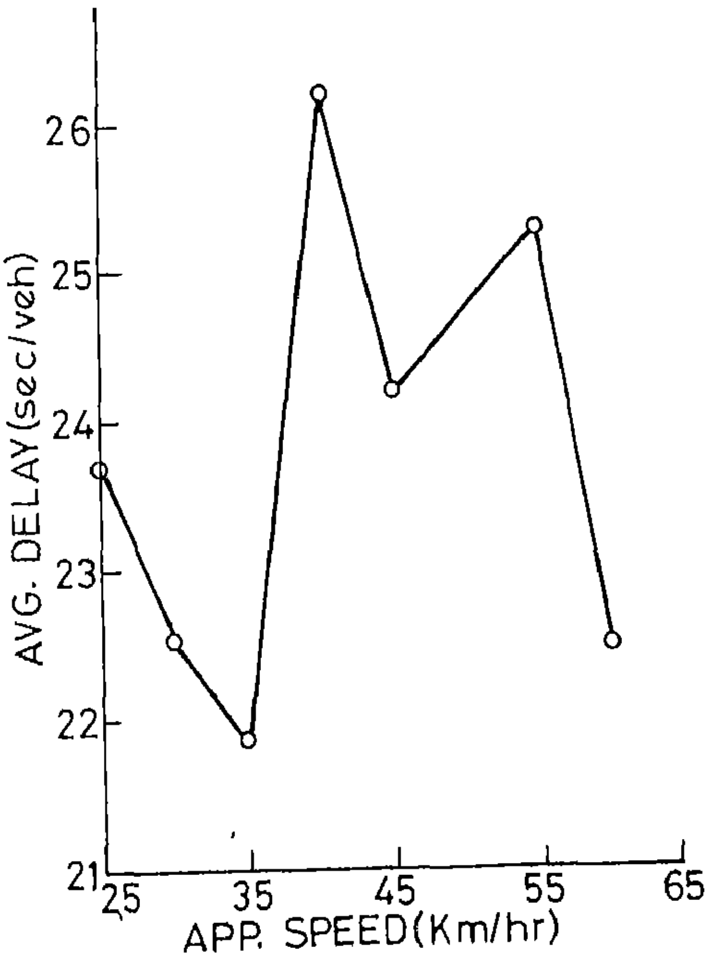


FIG.4·44 AVG. DELAY FOR VARYING APP. SPEED

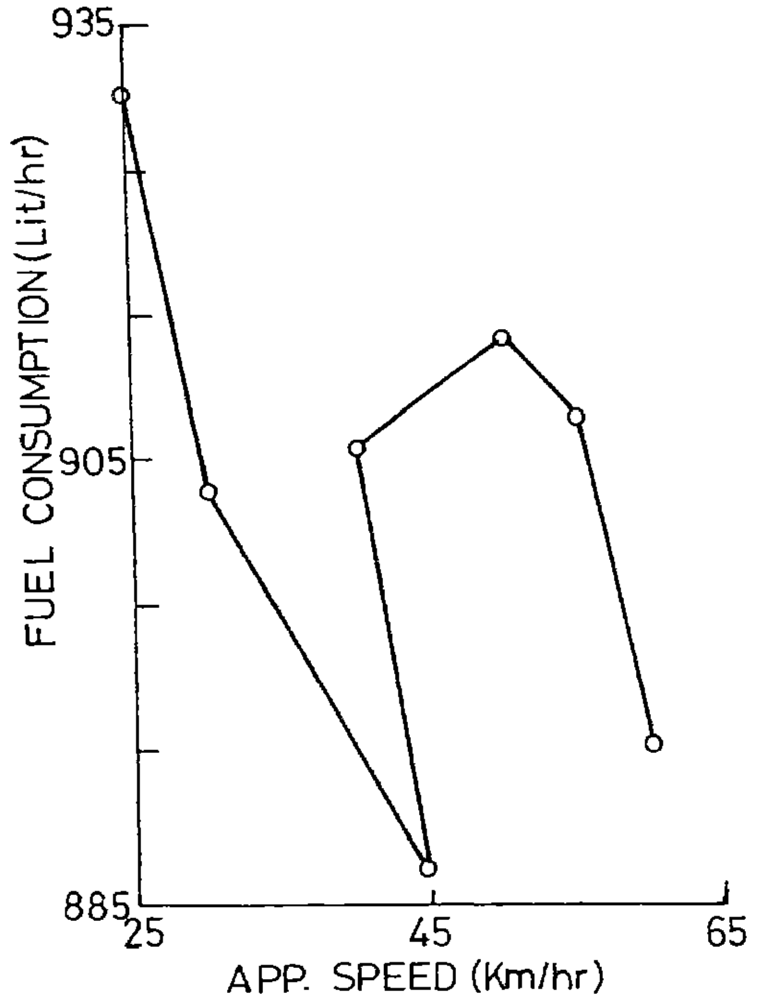


FIG. 4·47 FC AT VARYING APP. SPEED

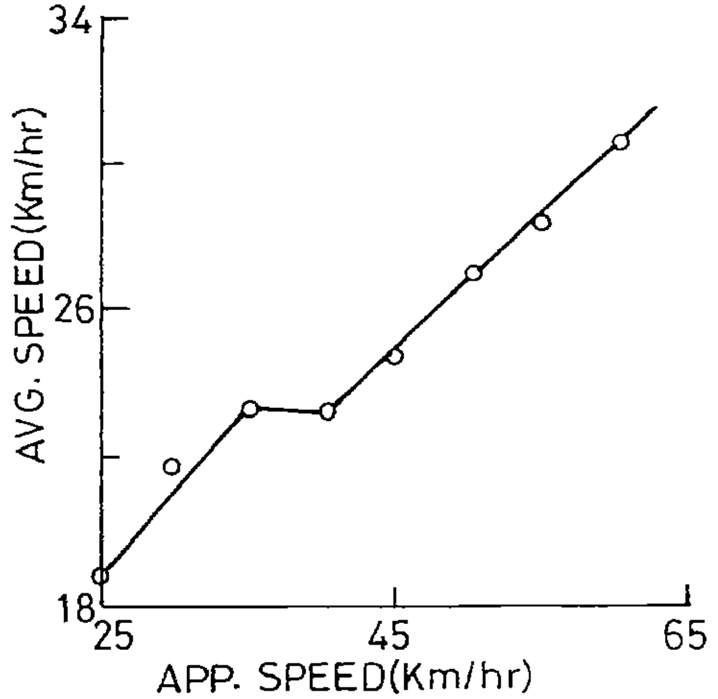


FIG. 4·48 AVG. SPEED FOR VARYING APP. SPEED

the stops percent remains constant as seen from graph in Fig. 4.45.

The PI initially decreases as the approach speed increases from 25 to 35 kmph indicating improvement in performance of the intersections as seen in Fig. 4.46. But from there onwards PI increases upto 50 kmph and then as speed increases further the PI decreases. The PI of the network is minimum at 60 kmph speed being 125.30.

The fuel consumption as seen from graph in Fig. 4.47 decreases initially as the approach speed increases upto 45 kmph, but from there onwards it increases steeply upto 50 kmph as approach speed increases. As approach speed further increases the fuel consumption decreases. The minimum fuel consumption is at 45 kmph speed being 886.77 lit/hr.

The average speed with which the vehicles travel actually increases as approach speed increases as it ought to be as seen from Fig. 4.48.

4.7.4 LINK LENGTH:

To test the sensitivity of the TRANSYT-7F model to intersection spacing it is varied from 500 m to 2000 m at 250 m step increase for every run. The other flow conditions are, flow level at 600 vph, speed at 30 kmph and PDF at 0.35. The MOE are evaluated for the best cycle length in each of the varied link length and the MOE values obtained are shown in Table 4.13.

The best cycle length (55 sec.) remains the same as the link length increases from 500 m to 1250 m, and from there onwards it shows a alternating decreasing and increasing trend as link

TABLE 4.13 : PERFORMANCE TABLE - LINK LENGTH IMPACT STUDY

Volume of flow : 500 VPH Speed : 30 KMPH

P F : 0.35

Link Length (m)	Best Cycle Length Sec	Average Delay Sec/Veh	Total Uniform Stops ./.	Total fuel Consum-ption	PI	Average Speed Kmph
500	55	22.55	81	904.57	128.34	21.80
750	55	23.08	84	1234.69	132.31	23.88
1000	55	23.34	86	1561.65	134.23	25.11
1250	55	23.59	86	1887.54	135.53	25.92
1500	50	23.90	86	2212.63	135.87	26.48
1750	55	24.00	81	2538.18	137.43	26.92
2000	50	23.88	86	2859.44	136.27	27.29

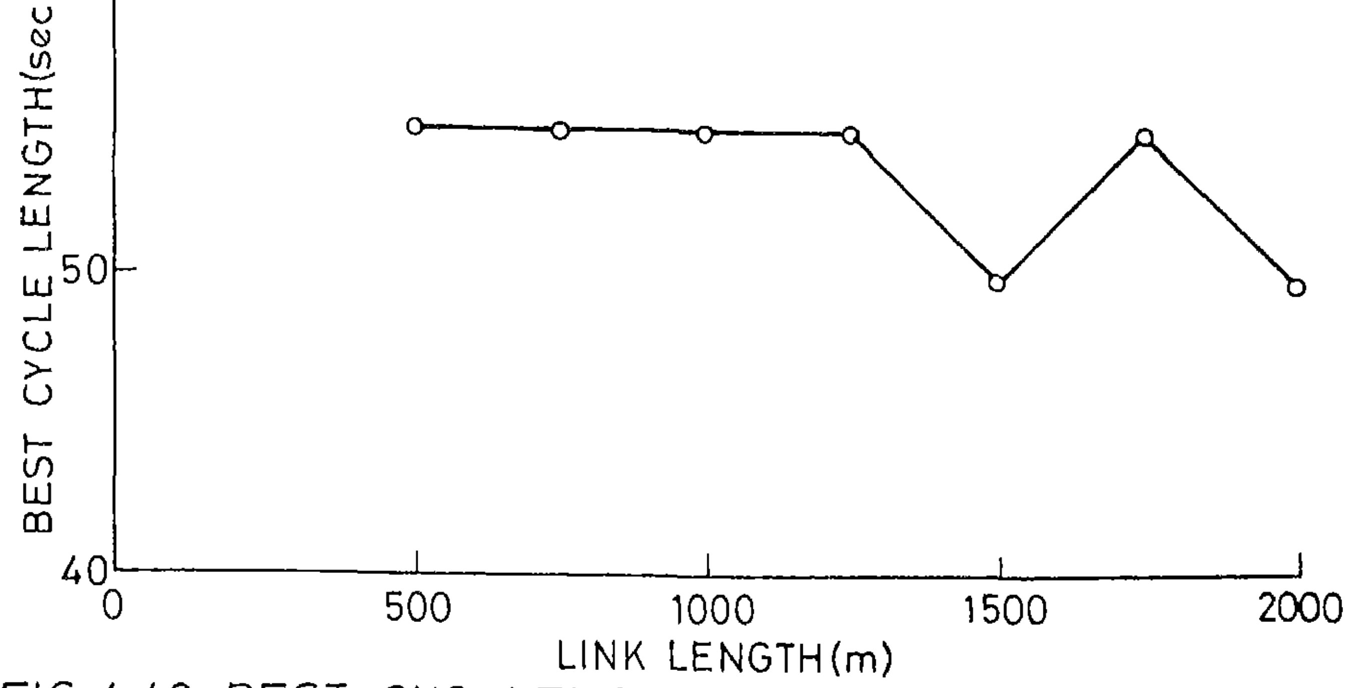


FIG.4·49 BEST CYC LENGTH FOR VARYING LINK LENGTH

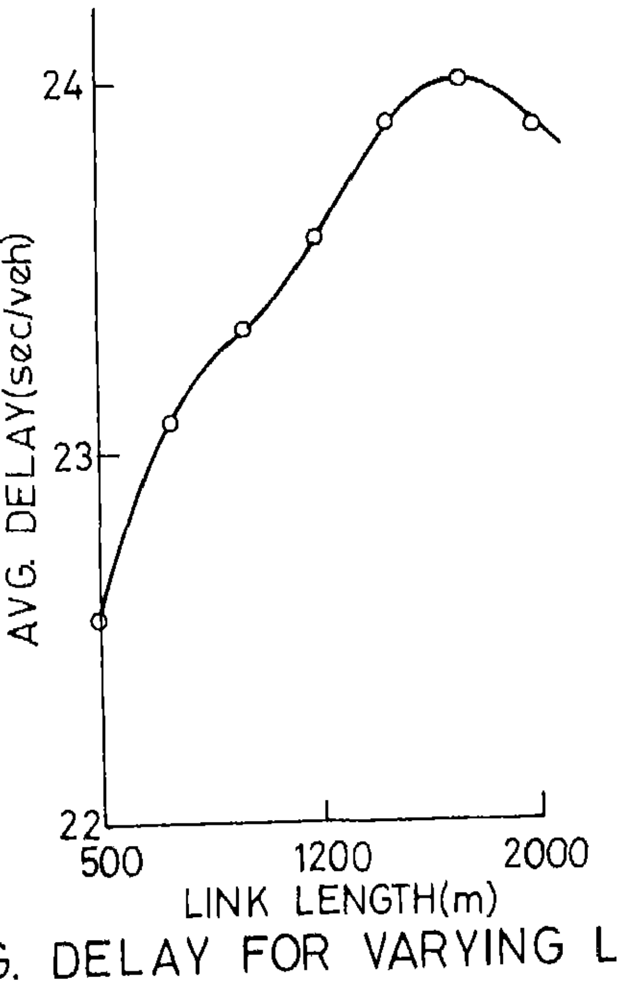


FIG.4·50 AVG. DELAY FOR VARYING LINK LENGTH

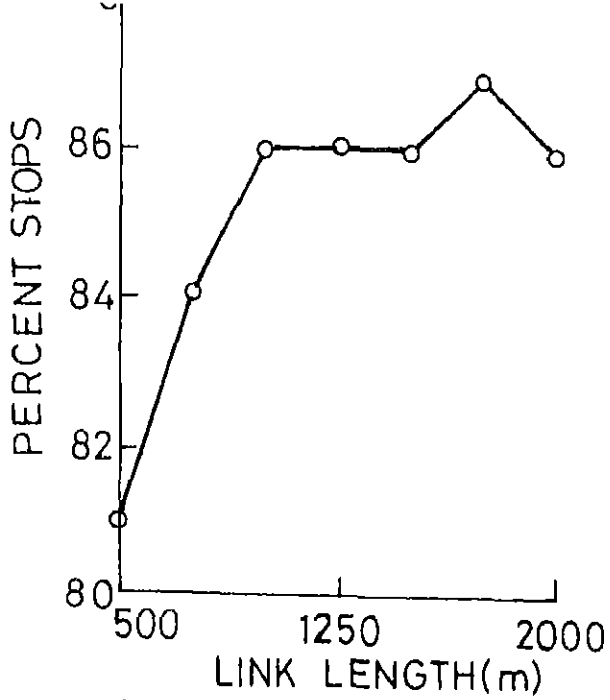


FIG.4·51 PERCENT STOPS FOR VARYING LINK LENGTH

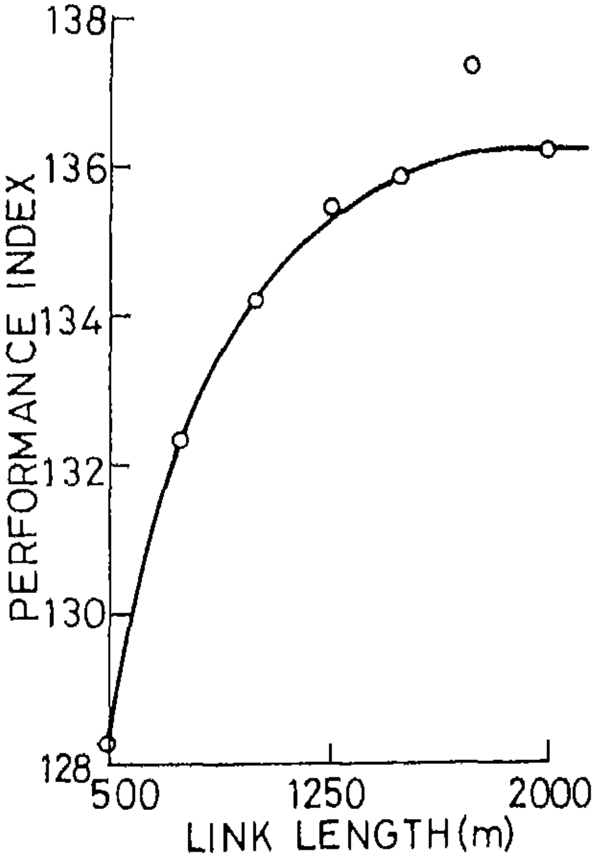


FIG.4·52 PI FOR VARYING LINK LENGTH

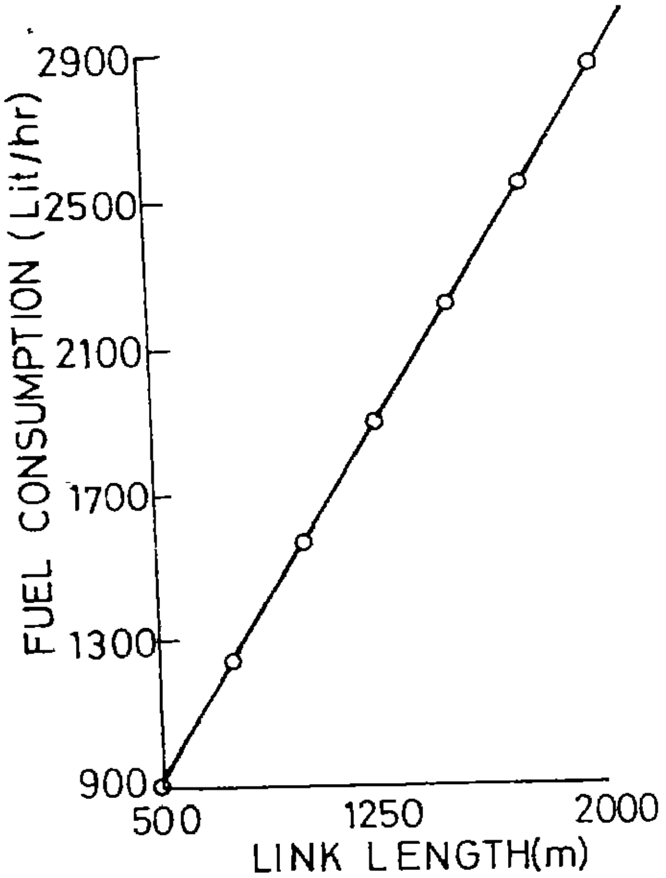


FIG.4·53 FC FOR VARYING LINK LENGTH

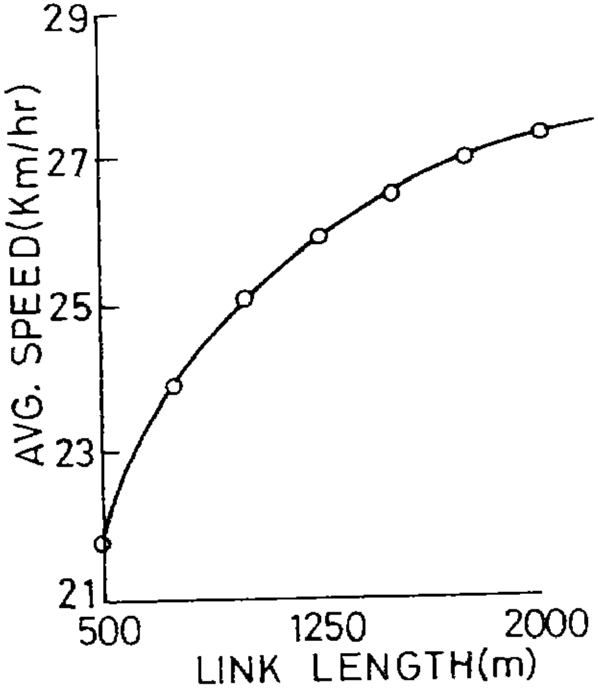


FIG.4·54 AVG. SPEED FOR VARYING LINK LENGTH

length further increases as seen from graph in Fig. 4.49.

The average delay (Fig. 4.50) increases as the link length increases upto 1750 m, but from there it starts decreasing. The average delay is the least at least intersection spacing value tried ie 500 m being 22.55 sec/veh. The stops percent increases as the link length increase initially. Thereafter it remains constant for spacing of 1000 m - 1500 m. Fràm there onwards it shows uneven trend as in Fig. 4.51.

The PI increases as the link length increases as seen from graph in Fig. 4.52 indicating that the model predicts good performance of intersections, for lower intersection spacing.

The fuel consumption shows a linear increase as the link length is increased as seen in Fig. 4.53. The average speed of the network also increases gradually as the intersection spacing is increased (Fig. 4.54) , since drivers tend to drive fast in that case not expecting a immediate stop ahead. Also the interactions among vehicles decrease to some extent.

4.7.5 PDF:

The sensitivity of the TRANSYT-7F model to variations in PDF is tested for values of 0.25, 0.35 and 0.5. During these runs the other flow conditions are link volume at 600 vph , speed at 30 kmph and link length at 800 m. The MOE for the best cycle length in each of the runs are evaluated and tabulated as given in Table 4.14.

The best cycle length for 0.25 and 0.35 PDF value is 55 seconds where as for 0.5 PDF value the cycle length is 60 seconds (Fig. 4.55).

TABLE 4.14 : PERFORMANCE TABLE - PDF IMPACT STUDY

Link Volume : 600 VPH Link Length : 500 m

Speed : 30 Kmph

PDF	Best Cycle Length	Average Delay Sec/Veh	Total Uniform Stop ./.	Total Fuel Consumption Lit/hr	PI	Average Speed KMPH
0.25	55	21.59	79	895.22	124.30	22.06
0.35	55	22.55	81	904.57	128.34	21.80
0.50	60	23.34	84	913.66	132.03	21.60

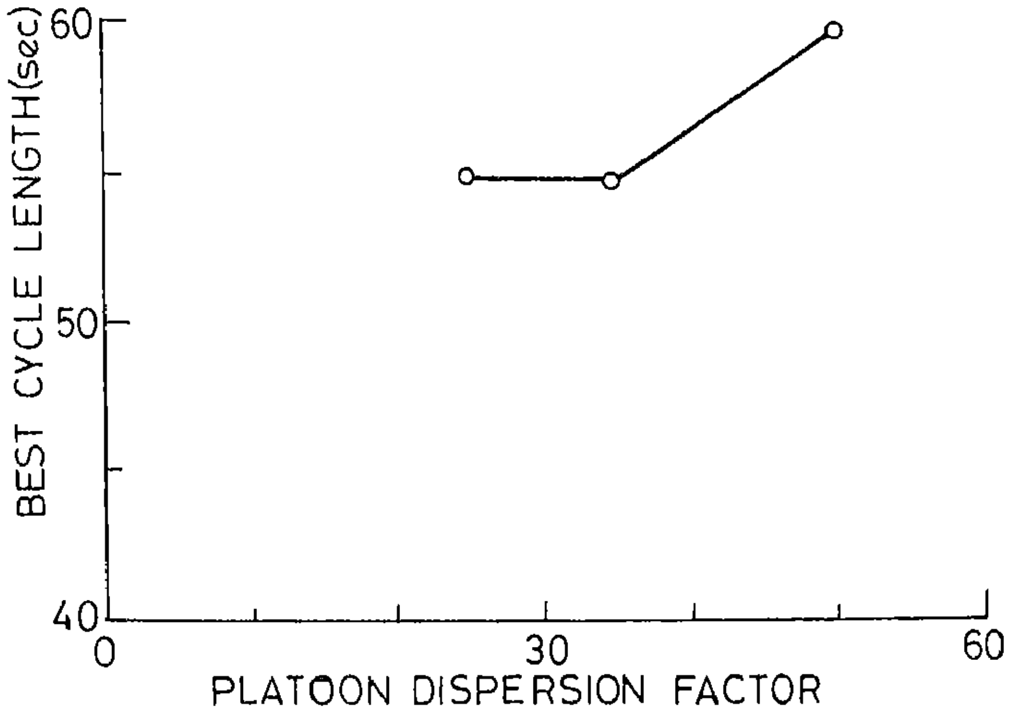


FIG.4·55 BEST CYC LENGTH FOR VARYING PDF

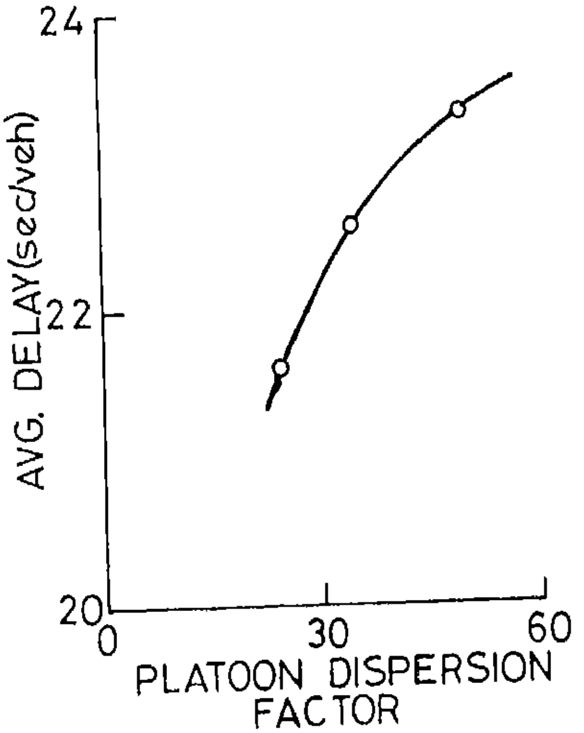


FIG.4·56 AVG. DELAY FOR VARYING PDF

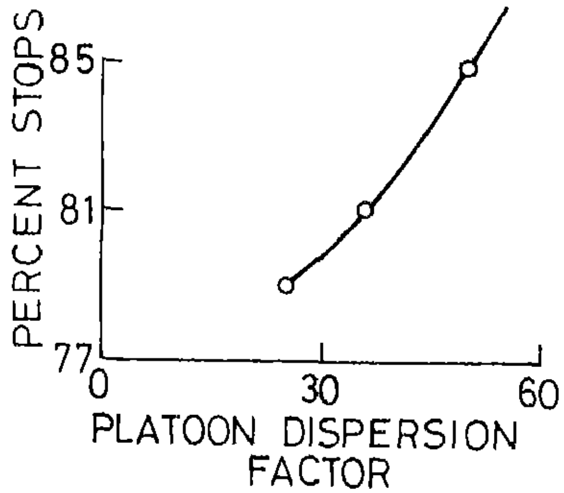


FIG.4·57 PERCET STOPS AT DIFFERENT PDF

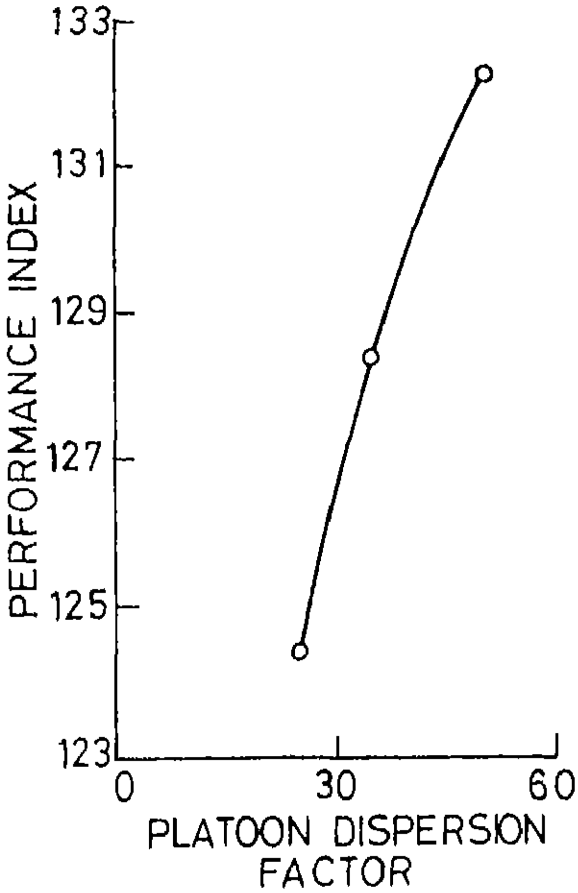


FIG.4·58 PI FOR VARYING PDF

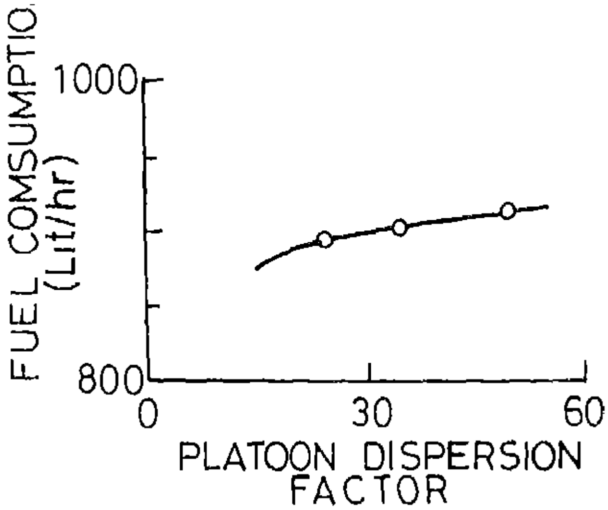


FIG. 4·59 FC FOR VARYING PDF

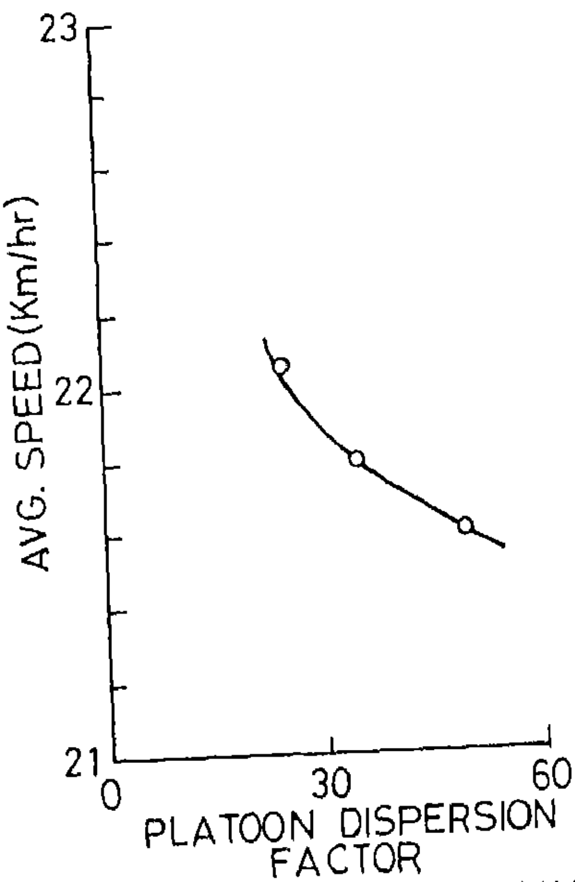


FIG. 4·60 AVG. SPEED FOR VARYING PDF

The average delay increases gradually from 21.59 secs at 0.25 PDF value to 23.34 secs at 0.5 PDF value as seen from graph (Fig. 4.56). The percent stops also increasé gradually as seen from graph (Fig. 4.59) as the PDF value increases.

The PI also increases from 124.30 at 0.25 PDF to 132.03 at 0.5 PDF (Fig. 4.58), indicating that the traffic performance of the signalized intersections degenerate as the conditions of road and flow characteristics of traffic degenerate, as the input value of 0.5 PDF suggests.

The fuel consumption increases as PDF value increase as seen from graph in Fig. 4.59. This is due to deteriorating road and traffic conditions as PDF increases.

The average speed of the vehicles in the network also decreases as seen from graph in Fig. 4.60 as PDF increases, owing to degenerating road characteristics and traffic flow conditions.

4.8 Comparison of Case Studies:

When the results of the two case studies are compared the following points are observed.

(1) As the cycle length parameter is increased from 45 secs to 70 secs, initially the MOE decrease reach a minimumm at the optimum cycle length and then again increase as the cycle length further increases in the case of both the case studies for a particular flow level, approach speed etc. But the traffic performance is more

sensitive to changes in cycle length in the case of six-intersection corridor, showing steep variations in MOE for changes in cycle length. Also the average delay, stops etc. experienced is more, in the case when the intersections are more, due to more vehicle interactions and stops at the intersection for want of green signal.

(2) When the flow level is between 300 vph - 600 vph, in both the case studies the 55 seconds cycle is the best. Also for other flow levels there is not much variations in cycle length of signal timing as the number of intersections is increased. The average delay and stops and fuel consumption are more when there are more intersections, as is observed in the second case study.

(3) With regard to speed variations, the traffic performance is more sensitive in the case of bigger corridor, with more intersections. As regard to link length and PDF variation study, the variations in performance of the intersections observed are almost similar in both the case studies.

CHAPTER 5

CONCLUSIONS

5.1 CONCLUSIONS:

As observed from the results of the two case studies considered, the following conclusions can be made regarding the impact of the flow characteristics and signal timing parameters on the performance of the signalized coordinated intersections as evaluated by the TRANSYT-7F model.

(1) For every particular flow level, approach speed, and intersection spacing there is one best cycle length at which all the MOE such as average delay, total uniform stops and fuel consumption are the least and the performance index of the network is also the least, and hence the best. The performance of the coordinated signalized intersection is the best at this optimum cycle length, and all the other signal timing Parameters such as phase length duration, offsets are to be developed for this cycle length. When the cycle length is input, the TRANSYT-7F evaluates the best cycle length in that range, optimizes the phase length and offsets for that cycle, and develops controller setting signal timing plans.

(2) When the traffic flow is uniform and the approach speed of flow of the vehicles is also uniform, coordination of the signals is not necessary. Also coordination of the signals is more effective when the intersection

spacing is less than when it is more. The coordination of the traffic signals for most of the traffic flow conditions decreases the average delay, stops of vehicles, fuel consumption, and hence the performance of the intersections improve.

(3) Volume of traffic or flow level is most important characteristic which affects the performance of the intersections as evaluated by the model. As the volume of traffic flow increases the intersection performance decreases due to more interactions among the vehicles causing more delay, stops, reduction in speeds etc. Hence for development of signal timing plans, a three dial controller, with three different signal settings that can implemented,one for the peak hour congested traffic (above 600 Vph), one for the normal traffic flow level (between 300 Vph - 600 Vph) and one for the off-peak hours when the traffic flow is less, can be used.

(4) Also observed from the case studies is that, performance of the signalized intersections is better at higher speeds (above 40 Kmph) rather than at lower speeds due to less interaction between the vehicles resulting in fewer stops, less delays and less fuel consumption.

(5) Also observed is the fact, that as the road characteristic and traffic conditions worsen the performance of the intersections deteriorate. Hence provisions of good road surfaces and traffic conditions such as better parking facilities, wider roads, etc. improve the performance of the signalized intersections.

5.2 RECOMMENDATIONS FOR FUTURE STUDY:

Some of the features on which further study can be made on the model are as follows.

(1) In the case studies considered, the intersections are junctions of major and minor roads. So some intersections where two major roads meet (so that equal importance is given to both streets) may also be included in the corridor and further study made to evaluate the performance of signalized intersections. Also a example of network of roads can be considered and the study made.

(2) Actual field data regarding traffic and road characteristics can be collected for any of the major urban cities and the model used to predict the performance of the intersections and develop the signal timing plans so that we can get a better idea about its suitability to Indian conditions.

(3) Also the TRANSYT-7F flow model considers vehicle types like car only. Buses also can be modelled, but to represent the heterogeneous traffic on Indian roads, the program has to be modified to include several vehicle types that exists on Indian roads so that the predictions of the model are more appropriate for our Indian conditions of traffic and roads.

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```
        INTERACTIVE INPUT PROGRAM FOR TRANSYT-7F-TERMINAL OUTPUT
       ==========================================================

     RUN TITLE IS TO PROVIDE IDENTIFICATION FOR EACH TRANSYT7F RUN
     ONE TITLE IS REQUIRED FOR EACH RUN & IT IS ALWAYS
     THE FIRST INPUT CARD.TITLE CAN BE OF 80 CHARACTERS
     GIVE THE TITLE OF RUN:
*THREE INTERSECTION SENSITIVITY ANALYSIS
     THE FOLLOWING CARDS 1-10 ARE FOR NETWORK CONTROL
     CARD-1,IS COMPULSORY
     PAUSE
     Type G to Continue, X to Exit, T to trace.
     *
*G
     INPUT OF CARD TYPE 1-RUN CONTROL CARD-COMPULSORY
     ====================================================
     THIS CARD PROVIDES NETWORK WIDE PARAMETERS AND ESTABLISHES
     INPUT &  OUTPUT OPTIONS
     PAUSE
     Type G to Continue, X to Exit, T to trace.
     *
*G
     INPUT CARD TYPE NO(C11):
*1
     THE MINIMUM CYCLE LENTH IS TO BE INPUT:
     ==========================================
     TRANSYT-7F ASSUMES NETWORK WIDE CYCLE
     LENGTH AS SAME FOR FOR ALL NODES
     SOME NODES MAY OPERATE ON DOUBLE CYCLE
     LENGTH THEN INPUT  CYCLE LENGTH SHOULD BE EVEN NUMBERS
     RANGE:30-300SECONDS
     INPUT MINIMUM CYCLE LENGTH NOW(C12):
*30
     THE MAXIMUM CYCLE LENGTH IS TO BE INPUT:
     =============================================
     IF ONLY ONE CYC LENGTH IS INPUT FOR SIMULATION OR OPTIMIZATION RUN THEN
     MAXIMUM & MINIMUM CYCLE LENGTH SHOULD BE THE SAME
     RANGE:30-300 SECS
     NOW GIVE THE VALUE OF MAX CYC LENGTH(C13):
*70
     CYCLE LENGTH INCREMENT:-
     ==================================
     THIS CYC LENGTH INCREMENT SHOULD BE EVENLY DIVISIBLE INTO THE RANGE
     IF ONLY ONE CYC LENGTH IS INPUT,THEN INPUT 0 AS INCREMENT.
```

```
        THAT TRANSYT-7F CALCULATE THE INITIAL TIMINGS,CARD
        TYPE 2 IS REQUIRED & MUST CONTAIN ONLY THE NODE
        NUMBERS OF THE NODES FOR WHICH INITIAL TIMINGS
        WILL BE CALCULATED
        PAUSE
        Type G to Continue, X to Exit, T To trace.
        *
*G
        CARD USING OPTION:-
        IF THE INPUT IS:-
        N:YOU ARE NOT USING THIS CARD &PROCEED TO CARD-3
        Y:YOU USE THIS CARD & START INPUTTING.
        NOW GIVE YOUR OPTION(Y.OR.N):
*N
        CARD TYPE 4-OPTIMIZATION STEP SIZES CARD:-
        ===================================================
        THIS CARD MAY BE USED TO INPUT A LIST OF STEP SIZES
        FOR THE OPTIMIZATION HILL CLIMB PROCESS.IF IT IS INPUT
        IT MUST BE USED IN CONJUNCTION WITH CARD TYPES 50 OR 54
        PAUSE
        Type G to Continue, X to Exit, T To trace.
        *
*G
        NOW ARE YOU INPUTTING THIS CARD(Y.OR.N):
*N
        CARD TYPE 5-STOPS REDUCTION CARD
        ----------------------------------------
        This card is used to input a list of percentage stops
        associated with small values of delay.one card of this
        type may be input for each optimization or simulation
        run,If not input a default type card is generated.
        PAUSE
        Type G to Continue, X to Exit, T To trace.
        *
*G
        ARE YOU INPUTTING THIS CARD(Y.OR.N):
*N
        CARD TYPE-61-SENSITIVITY PARAMETER CARD.
        ----------------------------------------------
        This card is used to input a list of parameters to reduce
        run time of the program.The parameters limit the numbers
        of down stream links for which flow profiles will be
        re-calculated after a signal timing adjustment to an
        upstream node is made during the hill climbing process
        This card is used in conjunction with card types 4 or
```

RELEASE 4 JUNE, 1984
SPONSORED BY:
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC OPERATIONS

VERSION 2.0
DEVELOPED BY:
TRANSPORT AND ROAD RESEARCH LABORATORY
UNITED KINGDOM AND
TRANSPORTATION RESEARCH CENTER
UNIVERSITY OF FLORIDA

INPUT DATA REPORT FOR RUN 1

FIELDS: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

RUN TITLE CARD

LINE NO.	TITLE
1)	THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500

NETWORK CONTROL CARD

LINE NO.	CARD TYPE	MIN CYCLE	MAX CYCLE	CYCLE INCR.	SEC/STEP CYCLE	SEC/STEP NORMAL	LOST TIME	GREEN EXTEN.	STOP PENALTY	OUTPUT LEVEL	INITIAL TIMINGS	PERIOD LENGTH	SEC(0) PERC(1)	SPD(0) TIME(1)	ENGL(0) METR(1)	PUNCH DECK(1
3)	1	35	70	5	1	1	4	3	25	1	1	60	0	0	1	0

+++ 106 +++ WARNING + THE SEC/STEPS FACTOR IN FIELD 5 IS TOO SMALL FOR CYCLE LENGTHS ABOVE 60 SECONDS.
IT WILL BE INCREASED TO ALLOW A MAXIMUM OF 60 STEPS/CYCLE.

+++ 106 +++ WARNING + THE SEC/STEPS FACTOR IN FIELD 6 IS TOO SMALL FOR CYCLE LENGTHS ABOVE 60 SECONDS.
IT WILL BE INCREASED TO ALLOW A MAXIMUM OF 50 STEPS/CYCLE.

LIST OF NODES TO BE OPTIMIZED

LINE NO.	CARD TYPE															
4)	2	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0

RUN TITLE: THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500 PAGE 2

FIELDS: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

LINE NO.	CARD TYPE	MASTER NODE	DEF. CLEARANCES YELLOW	ALL-RED	SYSTEM SATFLOW	EXTERNAL SPEED	SYSTEM SYSTEM PDF	MASTER FUEL FACTOR	DATA VEHICLE LENGTH							
5)	10	1	0	5	0	30	0	0	0	0	0	0	0	0	0	0

--- PROGRAM NOTE --- NON-DEFAULT INPUT UNITS WERE SPECIFIED AS FOLLOWS:

* ENGLISH/METRIC UNITS IN METRIC

INTERSECTION 1

CONTROLLER TIMING DATA

LINE NO.	CARD TYPE	NODE NO.	OFFSET/ YLD.PT.	REF INT	INT1	INT2	INT3	INT4	INT5	INT6	INT7	INT8	INT9	INT10	INT11	DOUBL CYCL
6)	13	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0

INTERVAL DURATIONS (SECS. OR PERCENT)

PHASE TIMING DATA

LINE NO.	CARD TYPE	NODE NO.	START INTVL	VARIAB. INTVL	YELLOW INTVL	ALL-RED INTVL	PHASE MINTM. SECS.	LINKS MOVING IN THIS PHASE								CONT FLA
7)	21	1	1	1	2	3	15	101	103	0	0	0	0	0	0	0
8)	22	1	4	4	5	0	10	105	106	107	108	0	0	0	0	0
9)	23	1	6	6	7	0	10	102	104	0	0	0	0	0	0	0

LINK DATA

LINE NO.	CARD TYPE	LINK NO.	LINK LENGTH	SAT. FLOW	TOTAL VOL.	MID-BLK. VOL.	FIRST NO.	INPUT LINK VOL.	SPD/TT	SECOND NO.	INPUT LINK VOL.	SPD/TT	THIRD NO.	INPUT LINK VOL.	SPD/TT	QUEUE CAP.
10)	28	101	500	3400	450	0	0	0	0	0	0	0	0	0	0	20
11)	28	102	500	1600	51	0	0	0	0	0	0	0	0	0	0	20
12)	28	103	500	3400	440	0	203	400	30	206	20	30	207	70	30	20
13)	28	104	500	1600	51	0	203	20	30	206	16	30	207	15	30	20
14)	28	105	250	3400	210	0	0	0	0	0	0	0	0	0	0	20
15)	28	106	250	1600	41	0	0	0	0	0	0	0	0	0	0	20
16)	28	107	250	3400	210	0	0	0	0	0	0	0	0	0	0	20
17)	28	108	250	1600	41	0	0	0	0	0	0	0	0	0	0	20

INTERSECTION 2

CONTROLLER TIMING DATA

LINE NO.	CARD TYPE	NODE NO.	OFFSET/ YLD.PT.	REF INT	INT1	INT2	INT3	INT4	INT5	INT6	INT7	INT8	INT9	INT10	INT11	DOUBL CYCL
18)	13	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0

INTERVAL DURATIONS (SECS. OR PERCENT)

PHASE TIMING DATA

TABLE B.1

LINE NO.	CARD TYPE	NODE NO.	START INTVL	VARIAB. INTVL	YELLOW INTVL	ALL-RED INTVL	MINIM. SECS.	LINKS MOVING IN THIS PHASE								CONT FLAG
19)	21	2	1	1	2	3	15	201	203	0	0	0	0	0	0	0

RUN TITLE: THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500 PAGE 3

FIELDS:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
20)	22	2	4	4	5	0	10	205	206	207	208	0	0	0	0	0
21)	23	2	6	6	7	0	10	202	204	0	0	0	0	0	0	0

LINK DATA

LINE NO.	CARD TYPE	LINK NO.	LINK LENGTH	SAT. FLOW	TOTAL VOL.	MID-BLK. VOL.	FIRST NO.	INPUT VOL.	LINK.... SPD/TT	SECOND NO.	INPUT VOL.	LINK.... SPD/TT	THIRD NO.	INPUT VOL.	LINK.... SPD/TT	QUEUE CAP.
22)	28	201	500	3400	440	10	101	400	30	105	20	30	106	20	30	20
23)	28	202	500	1600	51	10	101	20	30	105	16	30	106	15	30	20
24)	28	203	500	1600	430	10	303	390	30	306	20	30	307	20	30	20
25)	28	204	500	1600	51	10	303	20	30	306	16	30	207	15	30	20
26)	28	205	250	3400	210	0	0	0	0	0	0	0	0	0	0	20
27)	28	206	250	1600	41	0	0	0	0	0	0	0	0	0	0	20
28)	28	207	250	3400	210	0	0	0	0	0	0	0	0	0	0	20
29)	28	208	250	1600	41	0	0	0	0	0	0	0	0	0	0	20

INTERSECTION 3

CONTROLLER TIMING DATA

LINE NO.	CARD TYPE	NODE NO.	OFFSET/ YLD.PT.	REF INT	INT1	INT2	INT3	INT4	INT5	INT6	INT7	INT8	INT9	INT10	INT11	DOUBL CYCL
30)	13	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0

(INTERVAL DURATIONS (SECS. OR PERCENT) .... for INT1–INT11)

PHASE TIMING DATA

LINE NO.	CARD TYPE	NODE NO.	START INTVL	VARIAB. INTVL	YELLOW INTVL	ALL-RED INTVL	MINIM. SECS.	LINKS MOVING IN THIS PHASE								CONT FLAG
31)	21	3	1	1	2	3	15	301	303	0	0	0	0	0	0	0
32)	22	3	4	4	5	0	10	305	306	307	308	0	0	0	0	0
33)	23	3	6	6	7	0	10	302	304	0	0	0	0	0	0	0

LINK DATA

LINE NO.	CARD TYPE	LINK NO.	LINK LENGTH	SAT. FLOW	TOTAL VOL.	MID-BLK. VOL.	FIRST NO.	INPUT VOL.	LINK.... SPD/TT	SECOND NO.	INPUT VOL.	LINK.... SPD/TT	THIRD NO.	INPUT VOL.	LINK.... SPD/TT	QUEUE CAP.
34)	28	301	500	3400	430	0	201	390	30	205	20	30	208	20	30	20
35)	28	302	500	1600	51	0	201	21	30	205	15	30	208	15	30	20
36)	28	303	500	3400	450	0	0	0	0	0	0	0	0	0	0	20
37)	28	304	500	1600	51	0	0	0	0	0	0	0	0	0	0	20
38)	28	305	250	3400	210	0	0	0	0	0	0	0	0	0	0	20
39)	28	306	250	1600	41	0	0	0	0	0	0	0	0	0	0	20
40)	28	307	250	3400	210	0	0	0	0	0	0	0	0	0	0	20
41)	28	308	250	1600	41	0	0	0	0	0	0	0	0	0	0	20

GRAPH PLOT CARDS

LINE NO.	CARD TYPE	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	LINK NO.	
42)	40	103	104	201	202	203	204	301	302	0	0	0	0	0	0	0

RUN TITLE: THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500 PAGE 4

RUN CARD

FIELDS:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LINE NO.	CARD TYPE															
43)	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

--- PROGRAM NOTE --- A CARD TYPE 52 CAUSES RUN TO BE OPTIMIZED USING THE DEFAULT NORMAL OPTIMIZATION STEP SIZES.
IF CARD TYPE 4 WAS INPUT, IT IS IGNORED.
THE ABOVE WILL BE PROCESSED AFTER THE "BEST" CYCLE LENGTH HAS BEEN SELECTED.

--- PROGRAM NOTE --- NO ERRORS DETECTED, TRANSYT-7F NOW BEGINS FINAL PROCESSING.
IF ERRORS ARE DETECTED, FURTHER PROCESSING IS SUSPENDED.

--- PROGRAM NOTE --- THERE ARE A TOTAL OF 3 NODES AND 24 LINKS (INCLUDING BOTTLENECKS, IF ANY) IN THIS RUN.

--- PROGRAM NOTE --- THERE WERE A TOTAL OF 2 WARNING MESSAGES ISSUED IN THE ABOVE REPORT.

RUN TITLE: THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500 PAGE 5

TABLE B.1 Contd..

CYCLE EVALUATION SUMMARY PERFORMANCE

CYCLE LENGTH (SEC)	STEP SIZE (STEPS)	AVERAGE DELAY (SEC/VEH)	PERCENT STOPS (%)	FUEL CONSUMPTION (GAL/HR)	PERFORMANCE INDEX	NUMBER SATURATED LINKS
35	35	105.09	77	608.1	153.7	1
40	40	29.30	89	349.3	60.9	1
45	45	16.18	76	303.0	43.5	0
50	50	15.55	69	297.8	40.1	0
55	55	15.43	67	297.2	39.8	0
60	60	16.23	68	300.3	41.1	0
65	60	16.63	69	302.0	41.9	0
70	60	17.89	66	305.2	42.4	0

BEST CYCLE LENGTH = 55 SEC. CYCLE SENSITIVITY = 67.8 %
--- PROGRAM NOTE --- TRANSYT-7F OPTIMIZES THE SYSTEM USING THE BEST CYCLE LENGTH AND HILL-CLIMB STEP SIZES AS INDICATED BY CARD TYPE 52.

TRANSYT-7F: THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500 55 SECOND CYCLE 55 STEPS PAGE 6

<PERFORMANCE WITH OPTIMAL SETTINGS>

NODE NO	LINK NO	FLOW (VEH/H)	SAT FLOW (VEH/H)	DEGREE OF SAT (%)	TOTAL TRAVEL (VEH-KM/H)	TOTAL TIME (VEH-H/H)	DELAY UNIFORM (VEH-H/H)	DELAY RANDOM (VEH-H/H)	DELAY TOTAL (VEH-H/H)	AVERAGE DELAY (SEC/VEH)	UNIFORM STOPS (VEH/H;%)	MAX BACK OF QUEUE (VEH/LK)	QUEUE CAPACITY (VEH/LK)	FUEL CONSUM (LT/H)	PHASE LENGTH (SEC)	LINK NO
1	101	450	3400	33	225.00	8.97	1.43	0.04	1.47	11.7	283.4(63%)	5	20	33.29	32	101
1	102	51	1600	35	25.50	1.23	0.33	0.05	0.38	26.9	45.1(88%)	2	20	4.47	10	102
1	103	440	3400	32	220.00	8.31	0.94	0.04	0.98	8.0	200.8(46%)	4	20	30.67	32	103
1	104	51	1600	35	25.50	1.22	0.32	0.05	0.37	25.9	46.2(91%)	1	20	4.44	10	104
1	105	210	3400	42	52.50	3.08	1.25	0.08	1.33	22.8	179.4(85%)	3	20	11.41	13	105
1	106	41	1600	18	10.25	0.59	0.24	0.01	0.24	21.5	34.0(83%)	1	20	2.18	13	106
1	107	210	3400	42	52.50	3.08	1.25	0.08	1.33	22.8	179.4(85%)	3	20	11.41	13	107
1	108	41	1600	18	10.25	0.59	0.24	0.01	0.24	21.5	34.0(83%)	1	20	2.18	13	108
1 :		1494	MAX =	42	621.50	27.05	5.99	0.35	6.34	15.3	1002.4(67%)			100.06	PI =	13.3
2	201	440	3100	31	217.50	8.16	0.87	0.03	0.91	7.4	187.1(43%)	3	20	30.06	33	201
2	202	51	1600	35	23.00	1.14	0.33	0.05	0.37	26.3	46.3(91%)	1	20	4.16	10	202
2	203	430	1600	64	212.50	8.41	1.03	0.29	1.32	11.1	256.0(60%)	5	20	31.17	33	203
2	204	51	1600	35	23.00	1.14	0.33	0.05	0.37	26.4	46.4(91%)	1	20	4.16	10	204
2	205	210	3400	49	52.50	3.17	1.30	0.11	1.42	24.3	184.2(88%)	3	20	11.70	12	205
2	206	41	1600	20	10.25	0.60	0.25	0.01	0.26	22.7	34.8(85%)	1	20	2.22	12	206
2	207	210	3400	49	52.50	3.17	1.30	0.11	1.42	24.3	184.2(88%)	3	20	11.70	12	207
2	208	41	1600	20	10.25	0.60	0.25	0.01	0.26	22.7	34.8(85%)	1	20	2.22	12	208
2 :		1474	MAX =	64	601.50	26.38	5.66	0.67	6.33	15.4	973.8(66%)			97.41	PI =	13.1
3	301	430	3400	32	215.00	8.14	0.93	0.04	0.97	8.1	215.1(50%)	4	20	30.17	32	301
3	302	51	1600	35	25.50	1.22	0.32	0.05	0.37	26.1	45.8(90%)	1	20	4.45	10	302
3	303	450	3400	33	225.00	8.97	1.43	0.04	1.47	11.7	283.4(63%)	5	20	33.29	32	303
3	304	51	1600	35	25.50	1.23	0.33	0.05	0.38	26.9	45.1(88%)	1	20	4.47	10	304
3	305	210	3100	42	52.50	3.08	1.25	0.08	1.33	22.8	179.4(85%)	3	20	11.41	13	305
3	306	41	1600	18	10.25	0.59	0.24	0.01	0.24	21.5	34.0(83%)	1	20	2.18	13	306
3	307	210	3400	42	52.50	3.08	1.25	0.08	1.33	22.8	179.4(85%)	3	20	11.41	13	307
3	308	41	1600	18	10.25	0.59	0.24	0.01	0.24	21.5	34.0(83%)	1	20	2.18	13	308
3 :		1484	MAX =	42	616.50	26.88	5.99	0.35	6.33	15.4	1016.4(68%)			99.57	PI =	13.4

TRANSYT-7F: THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500 55 SECOND CYCLE 55 STEPS PAGE 7

<SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

TOTAL DISTANCE TRAVELED (VEH-KM/H)	TOTAL TRAVEL TIME (VEH-H/H)	TOTAL UNIFORM DELAY (VEH-H/H)	TOTAL RANDOM DELAY (VEH-H/H)	TOTAL DELAY (VEH-H/H)	AVERAGE DELAY (SEC/VEH)	TOTAL UNIFORM STOPS (VEH/H-%)	TOTAL FUEL CONSUM (LT/H)	PERFORMANCE INDEX	SPEED (KM/H)	
1839.50	80.31	17.63	1.37	19.00	15.36	2992.6(67%)	297.04	39.78	22.90	<TOTALS>

TRANSYT-7F: THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500 55 SECOND CYCLE 55 STEPS PAGE 8

TABLE B.2

TRANSYT-7F SIGNAL CONTROLLER SETTINGS

NETWORK-WIDE SIGNAL TIMING DATA

SYSTEM CYCLE LENGTH = 55 SECONDS
MASTER OFFSET REFERENCE LOCATION = INTERSECTION NO. 1
ALL OFFSETS ARE REFERENCED TO THE START OF INTERVAL NO. 1 AT THIS SIGNAL.

INTERSECTION CONTROLLER SETTINGS

INTERSECTION 1

INTERVAL NUMBER :	1	2	3	4	5	6	7
INTVL LENGTH(SEC):	23	4	5	9	4	6	4
INTVL LENGTH (%):	43	7	9	16	7	11	7
PIN SETTINGS (%):	100/0	43	50	59	75	82	93
PHASE START (PH#):	1			2		3	
INTERVAL TYPE :	V	Y	R	V	Y	V	Y
LINKS MOVING :	101			105		102	
	103			106		104	
				107			
				108			

OFFSET = 0 SEC. 0 %.
THIS IS THE MASTER CONTROLLER.
+++ 193 +++ WARNING + THE OFFSET FALLS WITHIN 1% OF AN INTERVAL CHANGE POINT AT THE START OF INTERVAL NO 1.
+

TRANSYT-7F: THREE INTERSECTION CORRIDOR SENSITIVITY ANALYSIS-VOLUME-500 55 SECOND CYCLE 55 STEPS PAGE 9

INTERSECTION 2

INTERVAL NUMBER :	1	2	3	4	5	6	7
INTVL LENGTH(SEC):	24	4	5	8	4	6	4
INTVL LENGTH (%):	44	7	9	15	7	11	7
PIN SETTINGS (%):	100/0	44	51	60	75	82	93
PHASE START (PH#):	1			2		3	
INTERVAL TYPE :	V	Y	R	V	Y	V	Y
LINKS MOVING :	201			205		202	
	203			206		204	
				207			
				208			

OFFSET = 53 SEC. 96 %.

INTERSECTION 3

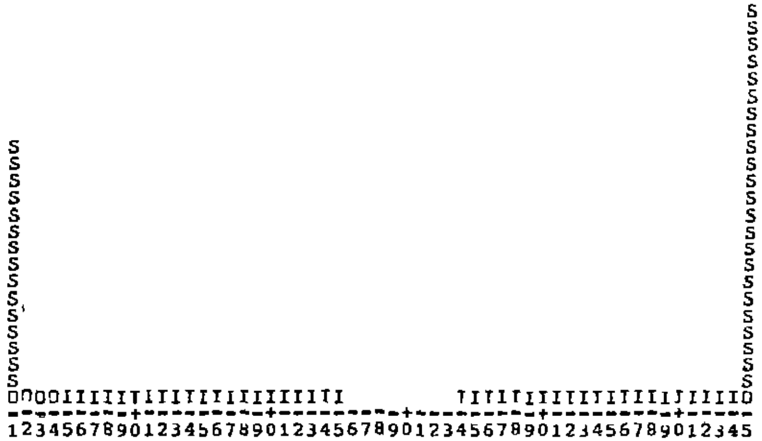
INTERVAL NUMBER :	1	2	3	4	5	6	7
INTVL LENGTH(SEC):	23	4	5	9	4	6	4
INTVL LENGTH (%):	43	7	9	16	7	11	7
PIN SETTINGS (%):	100/0	43	50	59	75	82	93
PHASE START (PH#):	1			2		3	
INTERVAL TYPE :	V	Y	R	V	Y	V	Y
LINKS MOVING :	301			305		302	
	303			306		304	
				307			
				308			

OFFSET = 0 SEC. 0 %.
+++ 193 +++ WARNING + THE OFFSET FALLS WITHIN 1% OF AN INTERVAL CHANGE POINT AT THE START OF INTERVAL NO 1.
+

TABLE B.3

```
1TRANSYT-7F: THREE INTERSECTION CORRIDOR  SENSITIVITY ANALYSIS-VOLUME-500          55 SECOND CYCLE     55 STEPS    PAGE 10
0                             < T R A N S Y T - 7 F   F L O W   P R O F I L E   D I A G R A M S >

   -KEY-  I :  ARRIVALS THAT QUEUE (NORMALLY ON RED).
          S :  DEPARTURES FROM QUEUE (NORMALLY AT THE SATURATION FLOW RATE).
          O :  ARRIVALS AND DEPARTURES ON GREEN.
        -,+ :  DELINEATORS ("+" MARKS EVERY TENTH STEP).
          N :  THE NUMBERS ACROSS THE BOTTOM ARE A TIME SCALE IN UNITS OF STEPS.
0NOTE: THE FLOW PROFILE DIAGRAM SHOWS EFFECTIVE GREEN AND RED, NOT ACTUAL.
       FURTHERMORE, THE "OFFSET" TO THE LINK EFFECTIVE GREEN HAS NOT BEEN
       ADJUSTED TO THE MASTER CONTROLLER, IF THERE IS ONE.
1TRANSYT-7F: THREE INTERSECTION CORRIDOR  SENSITIVITY ANALYSIS-VOLUME-500          55 SECOND CYCLE     55 STEPS    PAGE 11
0    LINK   103     MAX FLOW  3400 VEH/H      PLT. INDEX 0.39              LINK   104     MAX FLOW  1600 VEH/H      PLT. INDEX 0.29
```



```
     LINK   201     MAX FLOW  3400 VEH/H      PLT. INDEX 0.42              LINK   202     MAX FLOW  1600 VEH/H      PLT. INDEX 0.25
```

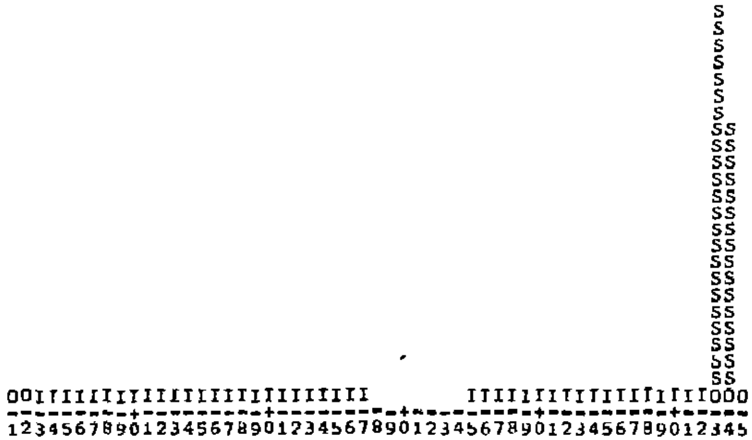


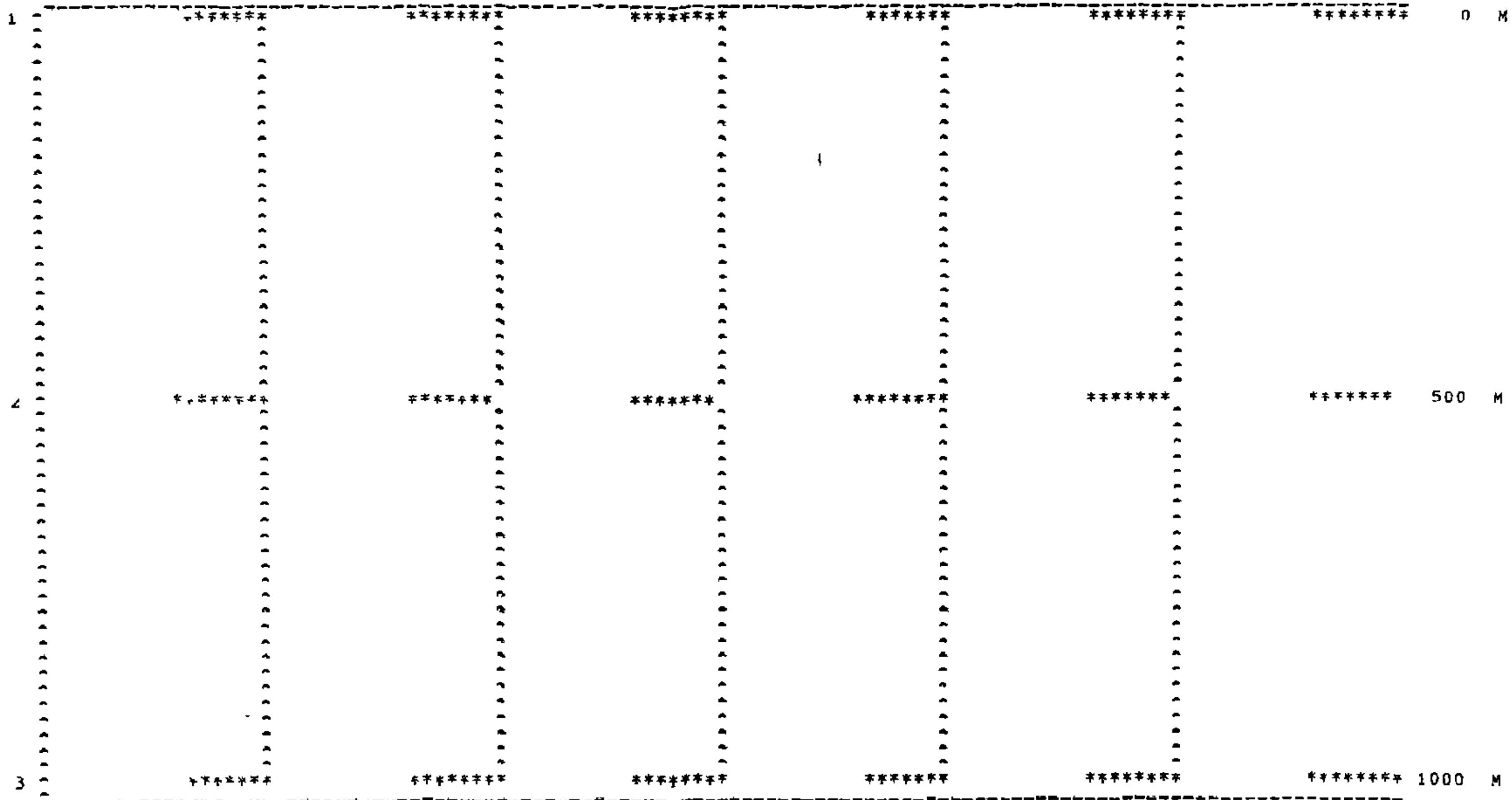
FIGURE B.1

```
NOTE: THE FLOW PROFILE DIAGRAM SHOWS EFFECTIVE GREEN AND RED, NOT ACTUAL.
      FURTHERMORE, THE "OFFSET" TO THE LINK EFFECTIVE GREEN HAS NOT BEEN
      ADJUSTED TO THE MASTER CONTROLLER, IF THERE IS ONE.
TRANSYT-7F: THREE INTERSECTION CORRIDOR  SENSITIVITY ANALYSIS-VOLUME-500          55 SECOND CYCLE    55 STEPS   PAGE 14
--- PROGRAM NOTE --- THIS IS THE INPUT DATA REPORT FOR TIME-SPACE DIAGRAM NO.  1
                                                TIME-SPACE  DIAGRAM  DATA
 LINE    CARD    NO.    TIME    TIME   DIST.
 NO.     TYPE   NODES   FLAG    SCALE  SCALE

 440)    60      3       1       0      0      0     0     0     0     0     0     0     0     0     0     0
 LINE
 NO.     TITLE                                           PLOT  TITLE  CARD
 450)     PLOT NODES 1 2 3
                                                   PLOT  LINK  STREAM  CARD
 LINE    CARD    LINK PAIRS ALTERNATING BY DIRECTION
 NO.     TYPE    DN. AND UP   DOWN AND UP   DOWN AND UP   DOWN AND UP   DOWN AND UP   DOWN AND UP   DOWN AND UP

 460)    61      101   103    201   203     301   303      0     0      0     0      0     0      0     0
TRANSYT-7F: THREE INTERSECTION CORRIDOR  SENSITIVITY ANALYSIS-VOLUME-500          55 SECOND CYCLE    55 STEPS   PAGE 15

                      < T R A N S Y T - 7 F   T I M E - S P A C E   D I A G R A M >
               PLOT NO.  1  PLOT TITLE:  PLOT NODES 1 2 3
               TIME AXIS IS THE SEC          TIME SCALE =   3 SEC/CHAR,  DIST. SCALE =   20  M/LINE
           1         2         3         4         5         6         7         8         9        10        11
 NODE  1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890   DISTANCE
```



```
 NODE  1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890   DISTANCE
                   2         3         4         5         6         7         8         9        10        11
       SCALE CONVERSIONS.                     +++ GREEN IN DOWN DIRECTION                  AVG. TIME DISPLACEMENT:
       TIME/INCH =  3 * 10 (AT 10 CHAR/INCH)       GREEN IN BOTH DIRECTIONS                 1200.00 / SPEED
       DIST/INCH = 20 * 6 (AT 6 LINES/INCH)   --- GREEN IN UP   DIRECTION
                                              *** RED   IN BOTH DIRECTIONS
TRANSYT-7F: THREE INTERSECTION CORRIDOR  SENSITIVITY ANALYSIS-VOLUME-500          55 SECOND CYCLE    55 STEPS   PAGE 16
                                              ITERATION CARD
```

Date Slip

This book is to be returned on the date last stamped.

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